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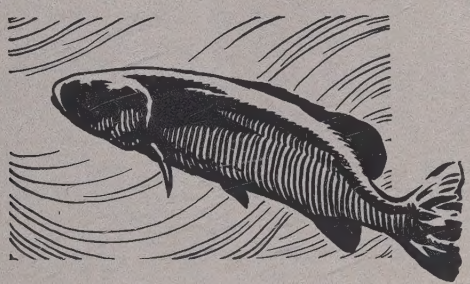

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

THE PROGRESSIVE FISH-CULTURIST

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TABLE OF CONTENTS

Page

The First Year of Federal Aid in Fish Restoration
-- Willis King 135

Experiments With Antibiotics and Vitamin B_{12} in the Diets of Brown Trout Fingerlings
-- L. E. Wolf 148

Absorption of Radioactive Calcium by Brook Trout
-- F. E. Lovelace and H. A. Podoliak 154

The School of Fisheries
-- Richard Van Cleve 159

A Note on Experiments Designed To Test the Viability of Gametes and the Fertilization of Eggs by Minute Quantities of Sperm
-- J. R. Nursall and A. D. Hasler 165

A Comparative Morphologic and Physiologic Study of Fish Blood
-- C. G. Smith, W. M. Lewis, and H. M. Kaplan 169

Walleyed Pike Fingerling Production in Drainable Constructed Ponds in Minnesota
-- Fred Miller 173

Rate of Survival of Largemouth Black Bass Fry Stocked in Experimental Farm Ponds
-- W. H. Brown 177

Items

Ascorbic Acid and Rhamnosides From Sea Water 153

Fertilization Experiments at Bare Lake, Kodiak Island 158

Scale Studies of the Lake Trout on the Great Lakes 168

An Improved Dip Net 172
Information Regarding Toxic Compounds or Effluents 176

Reprint
Farm Ponds--for Cattle or for Fish? by G. E. Hall 180

Clearing House 182

INDEX 183

THE FIRST YEAR OF FEDERAL AID IN FISH RESTORATION

The Dingell-Johnson Act in Operation

Willis King
U. S. Fish and Wildlife Service
Washington 25, D. C.

A REVIEW OF THE ACTIVITIES carried on by the States during the first year of the Federal Aid in Fish Restoration program provides clear evidence of achievement and even greater promise for the future. The 112 projects in action in the year ending June 30, 1952, have furnished highly essential factual information required in progressive fish management and have improved and enlarged fish habitats. Of still more general significance, perhaps, is the impetus this new program has given to all phases of the field of sport fish conservation. Seldom have the individuals--administrators, technicians, laborers, and (last but not least) the fishermen--engaged in fish conservation been so stimulated as they have been by the discussions, observations, and active planning related to Federal Aid in Fish Restoration.

TYPES OF PROJECTS

1. Investigational Projects. Although only 112 projects were put into action, a total of 154 projects were approved during the first fiscal year. It is significant that, of these 154 projects, 94 deal with fisheries investigations and amount to approximately 63 percent of the funds obligated. The emphasis placed on investigational work reflects the need of the States for basic information on the extent and potentialities of their sport fishery resources. The studies undertaken have emphasized surveys and general investigations, with 34 projects falling under this classification. Many of the surveys are on a State-wide basis; others are limited to specific watersheds or water areas. Although some States already had basic resource information on file, others had not conducted inventories of their aquatic resources prior to the availability of Federal Aid funds. Such information is essential to planning and executing an effective fish management program.

One of the most important groups of projects deals with finding out how to manage individual species or a combination of species within a given habitat. Of the 24 projects falling in this category, 13 deal with trout and trout streams and 6 deal with farm fishponds and their problems. Kentucky, Massachusetts, Montana, New York, North Carolina, and Oklahoma have projects specifically aimed at solving farm-pond problems. Studies which emphasize the harvest of fishes, particularly creel census of game species, have been popular projects, with 12 of these approved during the first year. There is a wide range of methods and techniques being used in creel census studies, depending in part on the nature of the fishing and the type of information desired.

Before undertaking large-scale development projects, six States are studying a variety of devices and techniques aimed at habitat improvements. Aquatic weed control, stream, lake and watershed improvement measures are being undertaken on an experimental basis, with the possibility that these may result in large-scale operations in future development projects. New Jersey's aquatic weed control experiments and Ohio's watershed management studies are good examples of this type of project.

Projects from California, New Jersey, and New York deal with marine fishes and coastal fishing. There is need for greatly expanded study in this field, and the initiation of investigational projects dealing with marine sport fishery resources is encouraged. The need for rough fish removal and the importance of this practice to the sport fishery is the subject of investigation by five States--Arizona, Florida, Georgia, Kentucky, and North Carolina. Two States--New York and Montana--have projects that are directly concerned with fish-cultural practices involving disease control and nutrition of hatchery trout.

2. Development Projects. Twenty-one projects aimed directly at the physical development or the applied management of fishery resources were approved, representing 24 percent of the total funds obligated. Five States have development projects dealing with the improvement of fish habitats. In addition, Florida is undertaking a water hyacinth control program, while Wisconsin is engaged in a watershed improvement program which promises to have far-reaching results. Three States--Idaho, Oregon, and Washington--are doing lake poisoning and reclamation under their Dingell-Johnson programs. Idaho and Hawaii are carrying out carefully planned stocking projects involving introduction of fish into unstocked waters. Colorado, Maryland, and Pennsylvania have had projects approved calling for the construction of new public fishing waters, while Arizona is enlarging the size of one of its public fishing lakes. Tennessee is carrying on fish rescue operations necessitated by periodic drawdown of certain reservoirs.

3. Land Acquisition. Only three States carried out land acquisition projects during the first year of program operation. Idaho and Nebraska purchased land for public fishing developments. Michigan is purchasing access sites to several public fishing waters. Land acquisition projects account for 3 percent of all funds obligated.

4. Coordination. In order to provide for proper supervision and planning of the Federal Aid in Fish Restoration programs, 30 States have set up coordination projects, as of June 30, 1952, obligating 10 percent of the money encumbered during the first year. Twenty-one States have combined Pittman-Robertson and Dingell-Johnson coordination under a single joint project. This method has many advantages, since the experience of the Pittman-Robertson coordinator can be used to good advantage in preparing project documents and in handling fiscal procedure and records. When an addition is made to the coordinator's staff, the new individual is ordinarily a fisheries management biologist. The other nine States have elected to keep the supervision of the Dingell-Johnson work entirely within their fish divisions. The Service recognizes that either of these systems may be equally effective, and the way is left open for the States to handle their coordination activities whichever way they prefer.

Table 1 summarizes the project history of the first year of program operation and shows the numbers of projects, amount of funds obligated, and percentages for each of the project types.

PROGRAM OPERATIONS

The program encompassing the activities that are reported here became a reality with the approval of the Dingell-Johnson Act (64 Stat. 430) on August 9, 1950. The source of funds is the 10-percent excise tax levied on sport fishing equipment, including only rods, reels, creels, and artificial lures, baits, and flies. Such items as lines, cane poles, sinkers, natural baits, nets, and plain hooks are exempt from the tax. In other words, the sport fisherman pays the bill, even though the benefits of the program will extend to all those who share in the sport fish resources of our fresh and marine waters. Tax collections for the first year of program operation amounted to $2,929,250.71. On all projects approved by the Fish and Wildlife Service for the Secretary of the Interior, and carried out in accordance with plans and specifications, the State may claim reimbursement for three-fourths of the money spent.

During this year 42 States and the 4 Territories and Island Possessions obligated nearly $1,500,000 in new projects. Much of this work was in addition to the fisheries programs carried on previously by the individual

TABLE 1.--Summary of projects by types and funds obligated

	Types of projects				Totals
	Coordination	Development	Investigation	Land	
States and Territories with approved projects----------	30	15	35	3	49
Number of projects of each type---	35	21	94	4	154
Percent of all projects----------	22.7	13.6	61.0	2.6	100
Total funds obligated----------	$149,386.84	$360,667.61	$945,911.87	$43,896.94	$1,499,863.26
Percent of all funds obligated---	10	24	63	3	100

NOTE: The above is based on all projects receiving approval, and for which funds were obligated during the fiscal year ending June 30, 1952. Forty-two of the projects consisted of renewals or new projects scheduled to start July 1, 1952.

States. Only three States had not submitted projects as of June 30, 1952, although several other States had obligated only a small part of their apportionments by that time. Because there was an unavoidable delay of 2½ months in making the initial apportionment of funds, the first year's program was slow in getting started, but reached a satisfactory pace by the end of the year. The States have until June 30, 1953, to obligate the first year's apportionment. Any unobligated balances remaining at that time, plus any future reversions from State projects, will go to the Fish and Wildlife Service to finance studies concerned with fishes of value for sport and recreation.

A complete résumé of the amount of the Federal apportionment, the net obligation of funds, and the unobligated balance as of June 30, 1952, is given for each State in table 2.

One of the original and primary conceptions of the program was that it would supplement and expand regular State programs, thus enabling the performance of investigations and developments for sport fishing which heretofore had not been possible. For this reason, the Act makes no provision for such necessary and related functions as law enforcement, publicity and education, and general administration of State programs.

TABLE 2.--Obligation of funds by States, Federal aid in fish restoration projects, fiscal year 1952

State	Total Federal apportionment	Net project obligations	Unobligated balance
Alabama	$30,614.73	$2,872.24	$27,742.49
Arizona	40,656.22	34,425.00	6,231.22
Arkansas	41,540.69	30,705.00	10,835.69
California	128,745.53	128,465.74	279.79
Colorado	60,154.98	60,154.98	.00
Connecticut	25,749.11	.00	25,749.11
Delaware	25,749.11	16,717.50	9,031.61
Florida	47,194.03	47,194.03	.00
Georgia	28,778.86	28,778.86	.00
Idaho	44,639.48	39,089.25	5,550.23
Illinois	87,396.55	31,339.01	56,057.54
Indiana	69,531.13	9,000.00	60,531.13
Iowa	52,284.29	7,989.75	44,294.54
Kansas	49,714.99	.00	49,714.99
Kentucky	44,653.68	35,448.75	9,204.93
Louisiana	25,749.11	.00	25,749.11
Maine	26,784.10	26,617.22	166.88
Maryland	25,749.11	19,745.35	6,003.76
Massachusetts	25,749.11	25,216.50	532.61
Michigan	128,745.53	8,625.00	120,120.53
Minnesota	128,745.53	12,620.02	116,125.51
Mississippi	30,189.44	.00	30,189.44
Missouri	80,830.55	60,723.75	20,106.80
Montana	61,819.56	60,866.25	953.31
Nebraska	44,703.56	33,378.19	11,325.37
Nevada	35,934.37	35,166.13	768.24
New Hampshire	25,749.11	25,749.11	.00
New Jersey	25,749.11	14,425.83	11,323.28
New Mexico	45,986.41	.00	45,986.41
New York	83,843.66	48,541.53	35,302.13
North Carolina	42,051.60	42,051.60	.00
North Dakota	27,015.14	20,136.62	6,878.52
Ohio	99,854.82	35,750.00	64,104.82
Oklahoma	61,043.30	11,827.79	49,215.51
Oregon	55,768.25	4,097.69	51,670.56
Pennsylvania	78,655.97	70,960.89	7,695.08
Rhode Island	25,749.11	12,693.22	13,055.89
South Carolina	25,998.43	17,038.12	8,960.31
South Dakota	36,769.11	36,769.11	.00
Tennessee	68,972.63	66,557.37	2,415.26
Texas	113,086.16	.00	113,086.16
Utah	35,327.19	8,325.00	27,002.19
Vermont	25,749.11	15,746.61	10,002.50
Virginia	40,607.62	38,025.00	2,582.62
Washington	65,433.80	39,942.46	25,491.34
West Virginia	37,289.79	37,289.79	.00
Wisconsin	117,995.75	117,995.75	.00
Wyoming	43,811.29	3,251.25	40,560.04
Alaska	75,000.00	35,130.00	39,870.00
Hawaii	25,000.00	22,420.00	2,580.00
Puerto Rico	10,000.00	10,000.00	.00
Virgin Islands	10,000.00	10,000.00	.00
Totals:	$2,694,910.71	$1,499,863.26	$1,195,047.45

NOTE: These figures represent only the Federal share of funds involved in all approved projects. The total estimated project costs are 1/3 more than the amount shown for each State. In the Territories, projects are usually 100 percent Federal financed. The above totals are based on 154 projects that received approval during the fiscal year ending June 30, 1952.

A COOPERATIVE PROGRAM

The Department of the Interior was named as the Federal agency to administer the Act, with authority given the Secretary to make rules and regulations for carrying out its provisions. The responsibility naturally fell to the Fish and Wildlife Service to represent the Secretary in the program, and within the Service responsibility was further placed in the Branch of Federal Aid. Close working relationships are maintained between the Service and the States, each partner in the program having definite responsibilities. The States select, plan, and execute projects and subsequently apply research findings to their management programs. The Federal Government is required to issue rules and regulations for carrying out the Act, make an annual report to Congress on activities and accomplishments, and review

all project proposals to insure that work contemplated is of a substantial character and that operations are in harmony with Congressional intent.

PROJECT HANDLING

In setting up projects, the same forms and procedures are used that have been employed under the Federal Aid in Wildlife Restoration program (Pittman-Robertson), with the result that there has been a minimum of confusion or delay in getting projects set up and approved. Careful planning is reflected in well-organized project documents and contributes substantially to accomplishments. Among the recognizable merits of first-class project planning are:

(1) Well-prepared documents provide the State administrator a ready reference to what his employee is doing and what can be expected from any project.

(2) A continual guide is afforded the project worker, which aids in keeping his attention focused on the principal problem. In the event of changes in personnel, a well-planned project can be taken over much more readily by a new leader than can one that is meagerly written or vague in objectives and procedure.

(3) Full and detailed information which the Act specifically requires is provided.

The experience of Federal Aid coordinators has been used to good advantage in preparing project documents in many States. Although no projects submitted by the States were rejected because they were basically contrary to the intent of the Dingell-Johnson Act, several have been returned because they were inadequately prepared and lacked the information necessary to a fair understanding of what was intended and how the work was to be carried out. In every instance where the Service has had to go back to the States, the deficiencies have been supplied, and there is reason to believe the State program has been strengthened as a result. The widespread public interest in the program demands that the project plans and reports give a complete description of the work proposed or in progress.

A list of all the Federal Aid in Fish Restoration projects which were approved and active during the first fiscal year is given in table 3. It is again pointed out that although 154 projects were approved, only the 112 projects which were active during the first fiscal year are shown in this listing. The remaining 42 projects included in the fiscal summaries were set up to begin actual operations as of July 1, 1952.

TABLE 3.--Federal Aid in fish restoration projects in operation during the year ending June 30, 1952

State	Type and title	Period	Estimated gross costs	Personnel
Alabama				
	R--Public Stream and Lake Investigations. (A preliminary survey to catalog the principal public fishing waters and compile information looking toward other Federal Aid projects.)	11/1/51 -- 4/30/52	$3,829.65	I. B. Byrd D. D. Moss
Arizona				
	R--Rough Fish Control in San Carlos and Lakeside Lakes. (To control excessive populations of carp, using chemicals.)	3/1/52 -- 6/30/53	4,400.00	Jack Hemphill
	R[1/]--Fisheries and Waterfowl Investigation of the Anderson Mesa. (A joint fish and waterfowl study covering seven lakes and concentrating on evaluation of habitat characteristics.)	1/16/52 -- 1/15/53	9,100.00	Richard A. Wagner
	D[1/]--Luna Lake Development. (The dam impounding waters for Luna Lake is being raised to improve the environment for fish and waterfowl.)	5/19/52 -- 12/31/52	29,400.00	
Arkansas				
	R--A Statewide Fisheries Survey. (Public fishing waters are being cataloged, streams classified, and fish populations examined.)	8/1/51 -- 7/31/52	37,790.00	Andrew Hulsey Bruce Crawford Robert Baker Leroy Gray

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Arkansas--continued				
	C--Fisheries Management Coordination.	1/1/52 -- 12/31/52	$3,150.00	Joe R. Hogan
California				
	R--Yellowtail Study. (Distribution and life history studies including a tagging program on this highly prized marine fish.)	11/15/51-- 6/30/52	25,000.00	Robert D. Collyer Ed. V. Dwyer
	R--A Study of the Catfish Fishery in California. (To study the distribution and catch of white catfish, channel catfish, and bullheads in central California.)	11/15/51-- 6/30/52	7,123.00	A. J. Calhoun David E. Pelgen
	R--Experimental Backcountry Fish Management. (A study of the trout waters in the high country to determine present fish populations and develop management information.)	4/1/52 -- 6/30/52	5,905.54	Scott M. Soule Robert Ehlers
	D--North Coastal Stream Restoration and Improvement. (Log jams and barriers are being modified or removed to open the way for migration of salmonids.)	3/1/52 -- 6/30/52	16,008.52	J. Bruce Kimsey Gerald R. Holman LeRoy T. Mongold
	R--Surf Fishing Investigation. (To collect data on the species taken and importance of the surf fishery in southern California.)	4/1/52 -- 6/30/52	5,000.00	Robert R. Ehlers Frederick B. Hagerman Jack Willard Schott
Colorado				
	R--Trout Lake Management Studies. (To determine the physical and biological characteristics of high mountain lakes and to carry out experimental management measures.)	7/1/51 -- 4/15/53	43,705.34	H. J. Williams P. T. Barrows C. A. Weberg James Boyd John Olive C. N. Feast II Richard Winternitz Ivan Wescoatt Richard Moore Charles Ward A. E. Anderson Philip A. Buscemi
	R--Creel Census Compilation. (To assemble information supplied by State wardens and to detect trends in fishing success.)	11/1/51 -- 6/30/52	876.00	W. D. Klein
	R--Trout Stream Studies. (To study the trout carrying capacity of the lower Yampa River and its tributaries.)	7/1/51 -- 4/15/52	4,894.00	Richard Alberti Carl Bailey
	C[1]--Fish and Wildlife Management Coordination.	7/1/51 -- 6/30/52	11,220.00	E. Kliess Brown[3] L. E. Riordan W. D. Klein
Connecticut				
	(No project in operation by June 30, 1952.)	-	-	-
Delaware				
	R--Fresh Water Investigations. (To survey streams and ponds and determine existing fish populations.)	1/1/52 -- 6/30/52	5,860.00	Jay L. Harmic
	D--Fresh Water Developments. (To reclaim State pond and Lake Como using rotenone, and to restock with bass, bluegills, and chain pickerel, accompanied by habitat improvements.)	5/1/52 -- 6/30/52	730.00	Jay L. Harmic

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Florida				
	C--Fishery Management Coordination.	11/1/51 -- 10/31/52	$7,731.61	John F. Dequine
	D--Noxious Vegetation Control. (To reclaim public fishing waters seriously infested with water hyacinth by spraying with 2,4-D.)	4/3/52 -- 2/28/53	25,526.87	Don R. Luethy
	R--Fish Population Control Investigation. (To supervise large-scale seining operations at Lakes Harris, Eustis, and Reedy, to record fish population data. Creel census studies are conducted on the same lakes.)	4/1/52 -- 3/31/53	29,666.90	Barry O. Freeman Edward T. Heinan Melvin T. Huish
Georgia				
	R--Warm Water Streams and Reservoirs Investigations. (To determine the fish populations of certain large streams and the possibilities of commercial harvest of nongame species.)	10/1/51 -- 6/30/52	21,093.00	William R. Holley
	C--Fisheries Management Coordination.	10/1/51 -- 6/30/52	4,180.55	Fred J. Dickson
Idaho				
	R--Utilization of Salmon River Drainage Spawning Areas by Spring Chinook Salmon. (Also to determine the fisherman use and economic value of the salmon fishery.)	7/1/51 -- 6/30/52	2,298.00	Forrest Hauck
	L--Caldwell Fish Management Area. (To provide for the purchase of the Caldwell area, including a 15-acre pond, for a public fishing site.)	5/28/52	2,525.00	-
	R--Biological and Economic Survey of the Fishery Resources in Lake Pend Oreille. (To determine the extent of the fishery resource and the possible effect of new dams now proposed or under construction.)	7/1/51 -- 6/30/52	15,259.00	Tim Vaughan[3/] Paul W. Jeppson
	D--Mirror Lake Fisheries Development. (To reclaim a 94-acre lake by poisoning and restocking with trout.)	5/1/52 -- 11/30/52	6,000.00	Tim Vaughan[3/] Paul W. Jeppson
	D--Golden Trout Introduction. (To stock at least 100,000 golden trout fry and fingerlings into 12 lakes which are now without game fishes.)	6/1/52 -- 9/30/52	2,700.00	Forrest Hauck Robert B. Irving
	R--A Random Creel Census of the Little Salmon River. (To determine the return to the creel of hatchery-produced fish and correctness of certain fishing regulations.)	4/15/52 -- 12/31/52	3,500.00	Leon W. Murphy
Illinois				
	R--Illinois-Mississippi Canal Fishery Investigation. (To study the biological characteristics of 104 miles of canal and to record the take of fish by anglers.)	3/15/52 -- 3/14/53	15,208.43	Morris L. Brehmer
	R--Fox Lake Fisheries Investigation. (To learn the take of fish by anglers from a 1,670-acre lake and its fish population picture.)	3/15/52 -- 3/14/53	24,251.15	Maurice A. Whitacre James K. Mayhew
Indiana				
	C--[1/]--Fish and Wildlife Management Coordination.	4/1/52 -- 6/30/53	12,000.00	Wm. B. Barnes

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Iowa				
	C[1/]--Fish and Wildlife Coordination.	9/1/51 -- 6/30/52	$5,750.00	Lester F. Faber
Kansas				
	(No project submitted by June 30, 1952.)	-	-	-
Kentucky				
	C--Fisheries Management Coordination	10/1/51 -- 9/30/52	7,943.00	Wm. A. Tompkins
	R--Kentucky Lake Investigations. (To determine the relationship between game and rough fishes and to select types of gear and seasons which may be employed in rough-fish control.)	11/1/51 -- 2/28/53	16,227.00	Ellis R. Carter
	R--Farm Pond Investigations. (To determine the effectiveness of several stocking ratios, using largemouth bass and bluegills in approximately 200 ponds. Fish populations of ponds with known history will be examined.)	11/1/51 -- 10/31/52	11,685.00	Wm. A. Smith
	R--Warm-water Stream Investigation. (To remove by poisoning the fish populations of two representative streams and to restock with game species to evaluate this management tool.)	3/1/52 -- 3/31/53	11,410.00	Harold L. Barber
Louisiana				
	(No project submitted by June 30, 1952.)	-	-	-
Maine				
	R--Trout Stream Management Investigation. (To study the habitat conditions in Sunkhaze Stream in relation to the production of brook trout, fish migration, and beaver-trout relationships.)	7/1/51 -- 6/30/52	4,397.00	Robert S. Rupp
	R--Investigation of Fresh-water Fisheries of Mt. Desert Island. (To determine the interrelationships of the more important species and to restore Atlantic salmon and alewives to some of the waters.)	7/1/51 -- 6/30/52	2,587.00	Keith A. Havey
	R--Investigation of Lake Trout in Cold Stream Pond Watershed. (To determine the status of the species and the extent of predation by eels.)	7/1/51 -- 6/30/52	2,968.00	Stuart E. DeRoche
	R--Statewide Survey of Obstructions to Fish Migration.	7/1/51 -- 6/30/52	1,484.00	Lyndon H. Bond
	R--Investigation of Eastern Brook Trout and Landlocked Salmon in Cold Stream Watershed.	7/1/51 -- 6/30/52	5,062.00	Lyndon H. Bond Robert E. Foye
	R--Reclamation of Potential Trout Ponds. (Removal of undesirable fishes from approximately 9 ponds, restocking with trout.)	7/1/51 -- 6/30/52	7,545.00	Robert E. Foye
	R--Ice Fishing Creel Census on Heavily Fished Trout and Salmon Lake.	2/1/52 -- 4/30/52	1,570.00	Stuart E. DeRoche
	C[1/]--Fish and Wildlife Management Coordination.	7/1/51 -- 6/30/52	8,556.62	Kenneth W. Hodgdon Harry W. Everhart Lyndon H. Bond

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Maryland				
	(No project in operation by June 30, 1952.)	-	-	-
Massachusetts				
	R--Stream Investigations. (A general stream survey with emphasis on the more heavily fished waters.)	10/1/51 -- 9/30/52	$22,500.00	James W. Mullan
	C--Fish Management Coordination.	3/1/52 -- 12/31/52	1,922.00	Richard H. Stroud
	R--Pond Management Investigations. (To analyze and evaluate existing information on 356 ponds, lakes, and reservoirs.	3/1/52 -- 12/31/52	9,200.00	Richard H. Stroud
Michigan				
	L[4]--Land Acquisition for Public Fishing Sites.	5/6/52	11,500.00	-
Minnesota				
	C[1]--Fish and Wildlife Management Coordination.	7/1/51 -- 6/30/52	6,270.00	-
Mississippi				
	(No project in operation by June 30, 1952.)	-	-	-
Missouri				
	R--Fisheries Management, Planning and Research Project. (A comprehensive inventory of aquatic resources involving surveys, tagging, creel census, and evaluation of management policies.)	12/1/51 -- 6/30/52	29,233.00	John L. Fund Perry Robinson Charles A. Purkett George G. Feener Edward Lowry Richard Marzolf
Montana				
	C--Fishery Management Coordination.	7/1/51 -- 6/30/52	10,200.00	Walter M. Allen Charles K. Phenicie
	R--Grayling Study. (To determine the status of the grayling in the Red Rock drainage and to propose constructive management measures.)	7/1/51 -- 6/30/52	4,900.00	Perry H. Nelson
	R--Effects of Irrigation Diversions on Stream and Lake Fish Populations. (To study particularly the movements of fish and mortality connected with diversions from the Gallatin River.)	7/1/51 -- 6/30/52	3,300.00	Wm. D. Clothier, Jr.
	R--Statewide Creel Census. (To compile catch data obtained by wardens, guides, and cooperating fishermen.)	7/1/51 -- 6/30/52	3,155.00	Chas. K. Phenicie
	R--Central Montana Fisheries Study. (To survey streams and reservoirs, determine fish populations with special studies on Prickly Pear Creek, Sheep Creek, and the Pishkun Irrigation Canal.)	7/1/51 -- 6/30/52	20,600.00	Nels A. Thoreson
	R--Southeastern Montana Fisheries Study. (To survey existing aquatic resources and to explore the management of ranch ponds for fish production.)	7/1/51 -- 6/30/52	12,400.00	A. N. Whitney
	R--Northwest Montana Fishery Study. (To determine present distribution and abundance of important game fish and the survival of hatchery-raised trout.)	7/1/51 -- 6/30/52	13,900.00	Frank A. Stefanich

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Montana--continued				
	R--Trout Disease and Nutrition Study. (To develop more satisfactory diets for hatchery fish and to procure and make available information on disease control.)	12/1/51 -- 6/30/52	$5,900.00	Jack E. Bailey
	R--Southwest Montana Fishery Study. (To inventory the waters of the region and record fisherman use and success.)	5/1/52 -- 4/30/53	6,800.00	Boyd R. Opheum
Nebraska				
	L--Grove Lake Acquisition. (Acquisition of a site for a public fishing lake.)	1/18/52 -- 5/9/52	47,407.50	-
Nevada				
	R--Investigations of Lakes Mead and Mohave. (To follow the changes which are occurring in the aquatic habitats and in the fish populations of these waters.)	7/1/51 -- 6/30/52	15,299.97	Al Ray Jonez[3/] Ed. V. Dwyer
	R--Stream and Lake Survey. (To inventory fishable streams and lakes.)	10/8/51 -- 6/30/52	17,677.80	Donald B. Thurston Ted C. Frantz
New Hampshire				
	R--Statewide Survey and Investigation of Lakes and Ponds. (To complete a state-wide inventory, determine fisherman use, and status of important species.)	7/1/51 -- 6/30/52	12,114.85	Arthur E. Newell
	R--Statewide Survey of Fishing Pressure and Fish Resources. (To inventory fish populations, to record economic importance of fishing in cooperation with New England-New York Inter-Agency Council.)	7/1/51 -- 6/30/52	5,838.08	Sumner A. Dole, Jr.
	R--Study of Bass Production in N. H. Waters. (To learn importance of smallmouth and largemouth bass in Bow and Squam Lakes, success of natural reproduction, and extent of removal of crop by anglers.)	7/1/51 -- 6/30/52	3,905.75	Ronald E. Towne Paul Giguere
	D--Warm Water Game Fish Management. (To rear bass experimentally and to use these fish for stocking selected waters.)	7/1/51 -- 6/30/52	5,335.15	Roger K. Warren
	R--Trout Stream Investigations. (An intensive investigation of Swift River and Stevens Brook to determine trout present, recovery of hatchery-produced fish, and data on fish migration.)	4/1/52 -- 4/30/53	7,138.32	Arthur E. Newell
New Jersey				
	R--Aquatic Weed Control. (To test several methods of controlling aquatic weeds and to observe the effects of the treatment on game fishes.)	1/1/52 -- 12/31/52	7,275.15	Robert K. Huckins
	R--Inventory of New Jersey Salt Water Fisheries. (To measure the extent of coastal fishing, its economic importance, and the relationship between commercial and sport fishing.)	2/1/52 -- 1/31/53	11,959.29	Roy Younger
New Mexico				
	(No project in operation by June 30, 1952.)	-	-	-
New York				
	R--Development and Improvement of Electric Shocker.	4/1/52 -- 3/31/53	4,200.00	D. C. Haskell

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
New York--continued				
	R--Selective Breeding of Trout. (To undertake the breeding of strains of brook and brown trout resistant to ulcer disease and furunculosis.)	4/1/52 -- 3/31/53	$8,500.00	Dr. Louis E. Wolf
	R--Weakfish Study. (To learn the commercial importance and important natural history data for the weakfish in the waters about Long Island.)	5/1/52 -- 4/30/53	25,000.00	Dr. Alfred Perlmutter Wm. S. Miller
	R--Management of Farm Fish Ponds and Bait Ponds. (To study stocking ratios and management techniques involved in farm fish ponds.)	4/25/52 -- 3/31/53	14,000.00	A. W. Zipper
	R--Restoration of Trout Fishing in a Chain of Connected Waters. (To determine the most effective means of reclaiming trout waters.)	4/21/52 -- 11/30/52	5,338.44	Robert G. Zilliox
	C[1/]--Fish and Wildlife Management Coordination.	4/1/52 -- 3/31/53	7,683.60	W. C. Senning
North Carolina				
	C--Fisheries Management Coordination.	7/1/51 -- 6/30/52	3,300.00	J. H. Cornell
	R--Fish Management Investigations of Coastal Streams. (To study the species composition, migration, and means of harvest of fish in three typical coastal streams, employing nets, traps, and tagging.)	7/1/51 -- 6/30/52	26,474.00	George D. Scruggs Robert M. Brown
	R--Fish Management Investigations of Farm Ponds. (To use several stocking ratios experimentally and to study the factors bringing about unbalanced fish populations in farm ponds.)	12/1/51 -- 11/30/52	8,354.00	W. E. Ellis
North Dakota				
	R--State-wide Fisheries Investigations. (To inventory fish resources with emphasis on newly created reservoirs and the formulation of management recommendations.)	4/17/52 -- 2/28/53	16,486.50	-
Ohio				
	R--Investigation of the Effects of Land Use Improvement on Stream Fisheries.	5/1/52 -- 4/30/53	40,000.00	Paul Shafer Frank Stinback
Oklahoma				
	R--Farm Pond Investigations. (To test several stocking ratios to arrive at suitable species and numbers of fish for stocking ponds.)	4/1/52 -- 3/31/53	9,646.50	C. M. Kramer
	C[1/]--Fish and Wildlife Management Coordination.	12/7/51 -- 6/30/52	3,427.50	Orville Curtis
Oregon				
	D--Malheur Reservoir Fishery Unit. (To provide public access to a trout lake.)	1/15/52 -- 6/30/52	677.60	Wayne A. Young
	C[1/]--Fish and Wildlife Management Coordination.	1/1/52 -- 12/31/52	4,785.98	A. V. Meyers

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Pennsylvania				
	D--Virgin Run Dam. (To provide for the construction of an earth fill dam to create a new public fishing water of approximately 32 acres.)	8/1/51	$94,614.52	Gordon L. Trembley
Rhode Island				
	R--Test-water Study of Trout Fishery. (To study fishing intensity, recovery of stocked trout, and management measures.)	4/28/52 -- 7/30/52	2,624.30	Chester T. Whaley
	R--Pond and Lake Survey. (To evaluate fishing potential and record environmental characteristics of the State's waters.)	6/1/52 -- 5/31/53	14,300.00	Chester T. Whaley
South Carolina				
	R--Investigation of Fish Populations in Reservoirs. (To explore possibilities for subimpoundments, the relation between fishing pressure and available fish resources, and the status of the striped bass in the Cooper-Santee Reservoirs.)	12/1/51 -- 11/30/52	20,295.00	William A. Garth
	C[1/]--Fish and Wildlife Management Coordination.	6/1/52 -- 5/31/53	2,422.50	James W. Webb
South Dakota				
	R--State-wide Fisheries Investigation. (To inventory fishable waters and to compile data on biological conditions, growth of fishes, and extent of winter kill.)	11/1/51 -- 6/30/52	20,614.00	Robert C. Gibbs Marvin O. Allum
Tennessee				
	R--Investigation of Waters Below Storage Reservoirs. (To study the changes in environment below storage dams and to develop management recommendations.)	7/1/51 -- 6/30/52	12,230.57	Donald W. Pfitzer
	R--Creel Census and Population Studies. (To study fishing success and fish populations in several reservoirs and at Reelfoot Lake.)	7/1/51 -- 6/30/52	20,215.25	John Parsons Carlos M. Fetterolf
	R--A Statewide Survey and Evaluation of Streams. (To inventory streams, with particular emphasis on smallmouth bass waters and studies on minnows and their harvest in relation to game fishes.)	1/1/52 -- 12/31/52	19,578.35	Eugene Ruhr Randolph Shields
	D--Fish Rescue and Tagging Project. (To recover and transfer game fishes left stranded by reservoir drawdown and to restore these fish to permanent water. A portion of the adult fish are tagged to assist in creel census and population studies.)	7/1/51 -- 6/30/52	6,519.70	Warren Currier[3/]
	C[1/]--Fish and Wildlife Management Coordination.	1/1/52 -- 6/30/52	4,112.17	James V. Padfield
Texas				
	(No project submitted by June 30, 1952.)	-	-	-
Utah				
	R--Summary of the Economics of Utah's Fishery. (To determine the importance of the sport fishery in three streams and three lakes, including an analysis of fish populations in those waters.)	9/1/51 -- 8/31/52	9,000.00	Wm. J. McConnell Glenn N. Taylor

See key and footnotes at end of table.

TABLE 3.--Federal Aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Vermont				
	R--Lake Champlain Fisheries Investigation. (To study the fishery resources with emphasis on a winter creel census and special studies of walleyes, largemouth bass, and northern pike.)	12/28/51--12/14/52	$7,190.46	Leonard C. Halnon
	R--Connecticut River Watershed Fisheries Investigation. (An inventory of the fish resources of tributary streams in the southern portion of the State.)	4/1/52 -- 3/28/53	9,756.97	James M. MacMartin
	C[1/]--Fish and Wildlife Coordination.	7/1/51 -- 6/30/52	4,048.05	Roger A. Seamans
Virginia				
	R--Game Fish Survey of the Impounded Public Fishing Waters. (Pre-impoundment studies on Buggs Island and Philpott Reservoirs on the Roanoke River, and post-impoundment studies on South Holston Reservoir and Claytor Lake, and to conduct a creel census and fishery resource study at Back Bay and other public fishing waters.)	7/1/51 -- 6/30/52	30,000.00	Dean A. Rosebery Robert G. Martin
Washington				
	D--Rehabilitation of the Little Pend Oreille Lake Chain. (To reclaim a series of six lakes totalling 378 acres, using rotenone.)	5/22/52 -- 12/31/52	18,650.46	Clarence F. Pautzke
	D--Sun Lake Rehabilitation Project. (To reclaim a series of four lakes totalling 1,181 acres, using rotenone.)	5/29/52 -- 6/30/53	19,169.04	Clarence F. Pautzke
West Virginia				
	R--Population Manipulation and Creel Census of Three West Virginia Smallmouth Bass Streams. (To sample fish populations and determine catch, particularly in Lost River.)	11/15/51--6/30/52	17,428.50	George D. Holton J. Walter Marron, Jr. Carl R. Sullivan, Jr.
Wisconsin				
	D--Area Watershed Stabilization (Management) Project. (To coordinate watershed development and improve habitats for fish life.)	2/1/52 -- 6/30/52	90,638.00	D. John O'Donnell
Wyoming				
	(No project in operation by June 30, 1952.)	-	-	-
Alaska				
	R--Game Fish Investigations of Alaska. (To determine fisherman use, gather catch statistics, and plan for the introduction of trout into barren waters.)	11/1/51 -- 6/30/52	35,130.00	Urban C. Nelson Roger W. Allin Robert C. Baade
Hawaii				
	D--Bluegill and Bass Stocking Program. (To introduce largemouth bass and bluegills into ponds believed suitable for these species.	8/1/51 -- 6/30/52	979.95	Yoshio Yamaguchi
	R--Fresh Water Game Fish Management Research. (To study the life histories of the freshwater Gobies, to introduce aquatic insects into certain trout streams, and to determine the desirability of introducing additional game fishes.)	11/1/51 -- 10/31/52	12,238.27	Yoshio Yamaguchi Kenji Ego

See key and footnotes at end of table.

TABLE 3.--Federal aid in fish restoration projects in operation during year ending June 30, 1952--Continued

State	Type and title	Period	Estimated gross costs	Personnel
Hawaii--continued				
	R--Reef and Inshore Game Fish Management Research. (To study the reef and shore fish resources of the Islands, looking toward establishment of management measures.)	1/1/52 -- 6/30/52	$5,841.61	Yoshio Yamaguchi Carl Nemoto
	C[1]--Fish and Wildlife Management Coordination.	10/1/51 -- 9/30/52	4,806.88	Vernon E. Brock
Puerto Rico				
	R--Puerto Rico Fish Surveys and Investigations. (To obtain biological data on 28 streams and 18 artificial lakes, to determine suitability for game fishes, and the nature of the present fish populations.)	2/15/52 -- 6/30/53	10,000.00	-
Virgin Islands				
	R--Investigation of Sport Fishing Potential. (To explore the possibilities for developing the sport fishery in both fresh and marine waters of the Islands.)	1/1/52 -- 12/31/52	10,000.00	-

KEY to symbols of project types: C--Coordination projects. R--Investigation projects. D--Development projects. L--Land acquisition projects.

[1] A combination D-J - P-R project.
[2] This project represents 2 segments, the first of which closed April 15, 1952.
[3] Resigned during the year.
[4] This project represents 2 segments, each providing for acquisition of access sites to public fishing waters.

GENERAL PROGRAM NEEDS

It will be apparent from a study of the projects currently in operation that new ideas in project types are not frequently encountered. In its initial phases the Federal Aid in Fish Restoration program has served mainly as a means of supporting a variety of work which had been contemplated by fishery administrators but never put into action because of a lack of adequate financing. In a few States, existing programs have been expanded, thus accelerating the rate of completion of programs of recognizable merit. In these respects the Dingell-Johnson Act is meeting the expectations of those who worked so long and assiduously to secure its passage.

It is particularly noteworthy that of the 112 projects in action last year, 76 were in the fact-finding category. This is a convincing demonstration of the realistic attitude of those participating in the program. There is general recognition that we do not have all the answers. In many ways, we have just begun to understand our fish management problems. More facts, less guesswork, are essential requirements for progress.

Yet if results are to keep pace with the stress of modern demands, if we are to secure the greatest possible benefit from the program, something more than an ordinary effort will be required. Long-range vision and sympathetic support, financial as well as moral, must be contributed by the men at the administrative level. There must be an ever increasing number of the technical personnel whose thinking is characterized by curiosity, originality, and imagination. In short, the future of this program, as of any other, is in the hands of the men in the States who are doing the actual work.

The first year's operations represent a creditable beginning and presage a continuous expansion of program contributions to sport fishing.

"Every acre of water is worth two acres of land if properly farmed."--Seth Green.

EXPERIMENTS WITH ANTIBIOTICS AND VITAMIN B_{12} IN THE DIETS OF BROWN TROUT FINGERLINGS

Louis E. Wolf
State Fish Hatchery
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DURING THE PAST TWO YEARS the use of vitamin B_{12} and antibiotics in the feeds given to chickens, turkeys, swine, and calves has passed the experimental stage. These substances are now in widespread use as additions to practical feed mixtures and apparently produce significant and economical growth stimulation in these animals.

The experiments described in this paper were performed to determine whether an increased growth rate could be obtained in trout through the addition of such supplements to their diets.

It seemed obvious that a basal diet for these experiments would have to be chosen with some care: if the basal diet were too good, no supplementation with vitamins or any other substance would be likely to improve the growth of the trout. When these experiments were planned, the literature on the use of vitamin B_{12} and antibiotics indicated that they were of greatest value in connection with the poorer, vegetable-protein diets. At present, claims are made that even the better rations (high in animal proteins) are improved through the use of such supplements (Lederle Laboratories 1952).

PART 1

It appeared advisable not to use liver as a basal diet, but to use a considerably poorer food or even one entirely lacking in any source of animal protein. Two basal diets were therefore prepared, one consisting entirely of vegetable meals (except for the inclusion of some gelatin which was necessary as a binder) and the other containing relatively small amounts (judged by current practices in trout feeding) of two animal meals. The former diet will be known as the A-1 diet, and the latter as the B-1 diet. The complete diet formulas are given in table 1. Both feeds had the consistency of a rather firm mush and were forced through a ricer before being given to the fish.

Four variations of each basal diet were made by adding the following supplements: Aurofac,[1/] Bi-Con APF-3,[2/] Bi-Con TM-5,[3/] and pure, crystalline vitamin B_{12}. As there was no information available as to the amounts to use in a trout diet, it was decided to start with approximately the amounts that had been recommended for farm animals. As there was no obvious benefit after a few weeks' use at these levels, the amounts were doubled and later doubled once more. The dosage schedule followed is given in detail in table 2.

The experiment began on May 11 and continued until August 30, a period of 16 weeks. The fish used were brown trout fingerlings, the average weight of which ranged from 1.405 to 1.660 grams in the different lots at the start. There were 200 fish in each lot. They were given all they would eat twice a day, 6 days a week, no feed being given on the seventh day. All lots were held in small experimental troughs receiving water direct from a pure spring-water supply. The water temperatures averaged 52° F.

All lots were weighed every 2 weeks. The initial and final average weights per fish of each lot are shown in table 3.

Mortality figures, covering 2-week periods, are given in table 4.

1/ Aurofac, by Lederle, contains not less than 1.8 grams of aureomycin hydrochloride per pound and not less than 1.8 milligrams of vitamin B_{12} activity per pound. Recommended by the manufacturer for use at a level not to exceed 1.4 percent of the diet of farm animals.

2/ Bi-Con APF-3, by Pfizer, contains 3 milligrams of vitamin B_{12} activity per pound.

3/ Bi-Con TM-5, by Pfizer, contains 5 grams of crystalline terramycin hydrochloride per pound.

TABLE 1.--Basal diets for tests of supplements

	Series A	Series B
Cottonseed meal	29 gm.	19 gm.
Soybean meal	29 gm.	19 gm.
Fish meal	-	10 gm.
Dry skim milk	-	10 gm.
Brewer's yeast[1/]	15 gm.	15 gm.
Rye flour, cooked	13 gm.	13 gm.
Gelatin[2/]	5 gm.	5 gm.
Mineralized salt[3/]	1 gm.	1 gm.
Lard	6 gm.	6 gm.
Cod-liver oil	2 ml.	2 ml.
Ascorbic acid	100 mg.	100 mg.
Total solids	100.1 gm.	100.1 gm.
Water	145 ml.	145 ml.

1/Standard Brands Inc., Type 50-B.

2/At the start of the experiment, it was hoped that no gelatin would be needed. For the first 2 weeks, both series of diets contained 18 grams of rye flour and no gelatin. It became necessary, however, to replace 5 grams of the flour with gelatin to obtain satisfactory binding.

3/Morton's Trace Mineralized Salt.

Discussion

The data in table 3 make possible a comparison of the total growth made by each lot during the 16-week period of observations. It will be seen that all the B-groups gained about twice as much as any of the A-groups. This difference, which is highly significant statistically, must be attributed to the presence of the fish meal and dried skim milk in the B-diets. None of the supplements added to the basal A-diet induced a growth stimulus approaching that which was caused by the two animal meals in the B-diets. Table 4 shows that the mortality figures were also very much lower in the B-groups than in the A-groups. This difference must likewise be attributed to the beneficial effect of fish meal and dried skim milk.

When the growth of each lot within a series is compared with the growth of the basal lot of that series (table 3), it is obvious that only in lot A-2 is there any possibility of growth stimulus from the supplement. Only Aurofac can be credited with a possible growth stimulus in the A-diets. In the B-diets, the increased growth from the addition of Aurofac was certainly too small to have any significance. Examination of the complete growth figures (not given here) indicates that what growth stimulus the Aurofac may have contributed to the A-diet occurred after the original amount had been doubled and quadrupled.

The total mortality figures for the A-series (table 4) reveal an apparent benefit, or a lowered mortality rate, from all the supplements except Aurofac. In the B-series, only the terramycin (lot B-4) compared favorably with the basal diet.

If the mortality figures for the second 8 weeks of the experiment are segregated, it will be seen that lots A-3 and B-3 exhibited the highest mortality. This was undoubtedly due to overdosage with APF-3 after the quantities had been doubled and redoubled (see table 2). In both lots the supplement was several times omitted from the diet for 3 days, whereupon fish losses ceased, only to resume when the supplement was restored to the diet.

In none of the lots did any distinctive pathological symptoms appear, either as lesions or in the behavior of the fish. No blood examinations were made, but inspection of gills indicated normal blood hemoglobin in all groups.

In the growth of the fish, one phenomenon which merits discussion was the peculiar initial loss of weight. Both series showed this trend, but it was much more pronounced in the A-groups. During the first 2 weeks, all lots lost weight. During the second 2 weeks, all except A-3 gained a very little but none caught up to its original weight. During

TABLE 2.--Dosage schedule used in tests of feed supplements, per batch (245 grams) of feed, during first 16-week experiment

Diet number	Supplement	First period[1/] Amount supplement	First period B_{12} mcg.	First period Antibiotic mg.	Second period[2/] Amount supplement	Second period B_{12} mcg.	Second period Antibiotic mg.	Third period[3/] Amount supplement	Third period B_{12} mcg.	Third period Antibiotic mg.
A-1 and B-1	None	-	-	-	-	-	-	-	-	-
A-2 and B-2	Aurofac	2.0 gm.	8.0	8.0	4.0 gm.	16.0	16.0	8.0 gm.	32.0	32.0
A-3 and B-3	APF-3	1.5 gm.	9.9	-	3.0 gm.	19.8	-	6.0 gm.	39.6	-
A-4 and B-4	TM-5	.4 gm.	-	4.4	.8 gm.	-	8.8	1.6 gm.	-	17.6
A-5 and B-5	B_{12}	10.0 mcg.	10.0	-	20.0 mcg.	20.0	-	40.0 mcg.	40.0	-

1/May 11 to June 6.

2/June 7 to July 30 in series A, and to August 7 in series B.

3/From July 31 in series A, and from August 8 in series B, to August 30.

TABLE 3.--Initial and final weights, average per fish, in grams

	Weights in lots									
	A-1	A-2	A-3	A-4	A-5	B-1	B-2	B-3	B-4	B-5
Start	1.61	1.50	1.52	1.41	1.44	1.60	1.66	1.53	1.56	1.66
End	4.63	4.86	3.92	4.26	4.30	7.84	7.91	6.99	7.50	7.69
Increase	3.02	3.36	2.40	2.85	2.86	6.24	6.25	5.46	5.94	6.03

the third 2-week period, all lots made fair growth and exceeded their original weights. Not until the fifth 2-week period, however, was the maximum growth rate attained.

It will be seen that the mortality rate also exhibited a peculiar trend. In all lots mortality was low during the first 2 weeks, then jumped, and did not begin to recede until the seventh and eighth weeks. It was not until the fifth 2-week period--about the time the fish also reached their maximum growth rate--that losses settled to a fairly even level. The partial exception to this behavior was lot A-3.

That these growth and mortality trends had nothing to do with the increased dosages of the supplements, is shown by the fact that lot A-1, receiving no supplement, acted the same as the other lots.

One possible explanation of these phenomena would be that some individual fish had sufficient physiological flexibility to adapt themselves to the basal diet. This adaptation required some 8 weeks, during which time the less flexible individuals succumbed. What occurred, therefore, was a selection for survival of fish with a certain type of biochemical constitution. It is interesting to speculate upon the inheritability of such biochemical types, and upon whether long-domesticated hatchery strains of trout are relatively at a disadvantage when compelled to consume natural trout food.

It is perhaps pertinent to this discussion to point out that Phillips and his associates (1949) observed what may have been a similar phenomenon during experiments with brown trout fingerlings. These fish were on diets low in biotin, a deficiency of which vitamin the Cortland group has found to be associated with the presence of "blue slime" disease. The Cortland workers found that mortality declined as the fish increased in size, biotin storage in the liver increased, and "blue slime" disappeared.

Summary

A 16-week experiment was conducted with fingerling brown trout to determine whether supplements of vitamin B_{12} and the antibiotics terramycin and aureomycin would stimulate growth.

Two basal diets were used, one consisting entirely of vegetable meals except for a small amount of gelatin for binding purposes, and the other containing in addition relatively small proportions of fish meal and dry skim milk.

Much better growth was obtained from the diets that contained the two sources of animal protein.

Supplementation with pure vitamin B_{12} did not stimulate growth but perhaps did slightly lower the mortality when added to the all-vegetable-meal diet.

Supplementation with vitamin B_{12} in the form of a marketed animal-feed supplement did not improve the growth rate and proved somewhat toxic at the higher levels during the experiment.

Supplementation with combined aureomycin and vitamin B_{12} may have slightly increased the growth rate on the vegetable-meal diet but had no effect in the better diet. It did not affect mortality.

Addition of terramycin to the diets did not stimulate growth but may have lowered the death rate slightly in both series of diets.

These experiments raised little hope that the antibiotics and vitamin B_{12} are beneficial in the diets of trout.

PART 2

At the conclusion of the work described in part 1, the fish were used in a modified

TABLE 4.--Mortality of trout by 2-week periods

Lot number	Mortality during weeks							
	2	4	6	8	10	12	14	16
A-1	1	24	34	16	4	1	2	0
A-2	1	27	28	14	3	4	2	1
A-3	1	6	21	12	6	12	3	2
A-4	0	11	29	13	5	2	1	0
A-5	1	15	29	9	5	5	3	1
B-1	1	3	4	5	1	0	1	0
B-2	1	0	10	4	3	0	4	0
B-3	0	1	4	4	1	2	12	11
B-4	0	2	2	2	0	1	1	0
B-5	1	1	4	4	6	2	1	3

continuation of the investigation for another 16-week period.

Lots A-1 and B-1 were continued on the identical diets used before. The fish in B-1 had become crowded and had to be distributed into two troughs. This distribution was made in a random manner so that duplicate lots (B-1a and B-1b) were available for statistical treatment of data.

Lots A-2 and B-2, and lots A-5 and B-5 were likewise continued on the same diets. Both B-lots were divided into two groups, B-2a and B-2b, and B-5a and B-5b.

Lots A-3 and A-4 were combined, and excess fish from lots A-2 and A-5 were added. This mixture was then divided at random into three groups hereafter called A-3, A-4, and A-6. These three lots were used to test whether the addition of one of the poorly absorbed sulfonamides, such as sulfaguanidine, used as an "intestinal disinfectant," would destroy intestinal bacteria capable of synthesizing vitamin B_{12} and so disclose a need for this vitamin in the fish. Three different levels of sulfaguanidine were employed in the three lots of trout, and it was planned to supplement the diets of these three groups with vitamin B_{12} if and when they began to show a declining growth rate or increasing mortality.

Lots B-3 and B-4 were combined and then divided into three groups hereafter called B-3, B-4, and B-6. Lots B-3 and B-4 were used to test whether the benefits which had been derived from the addition of fish meal and skim milk (part 1) were contributed by both meals or only one. Therefore, the diet formulas for these two lots were altered: lot B-3 then received dry milk but no fish meal, and lot B-4 received fish meal but no milk.

Lot B-6 was used in a sulfaguanidine test similar to that involving lots A-3, A-4, and A-6.

The new schedule of supplementation is given in table 5. It will be seen that in the lots which were continued from part 1, the dosages were reduced to those of the second period of table 2.

All fish were fed all they would eat, once a day, 6 days a week. No food was given on the seventh day. Water temperatures averaged 52° F., and each lot had its individual water supply. Although the fish were placed on the new diet schedule immediately after the conclusion of the first experiment, 1 week elapsed before weights could be taken.

The experiment was begun on September 6 and was continued to December 27, a period of 16 weeks. The fish were weighed every 2 weeks. Initial and final average weights are given in table 6. Mortality was so low in all lots that the figures have been omitted. Five lots lost no fish whatever; the greatest mortality was in the lot that lost seven fish during the first 6 weeks of the test.

Discussion

The data in table 6 show that the B-groups, in general, gained about twice as much weight as the A-groups. This growth differential was the same as that which occurred during the first 16 weeks (part 1) and was attributed to the fish meal and dried skim milk in the B-diets.

Lot B-4 (fish meal) gained a little more weight than lot B-3 (skim milk). Both meals apparently contained the growth factor responsible for the superior growth of the entire

TABLE 5.--Dosage schedule used in tests of feed supplements, per batch (245 grams) of feed, during second 16-week experiment

Diet number	Supplement	Amount supplement	B_{12} mcg.	Antibiotic mg.
A-1 and B-1	None	-	-	-
A-2 and B-2	Aurofac	4.0 gm.	16.00	16
A-5 and B-5	B_{12}	20.0 mcg.	20.00	-
A-3	Sulfaguanidine	.3 gm. (first 8 weeks)	-	-
	Sulfaguanidine	1.0 gm. (last 8 weeks)	-	-
A-4 and B-6	Sulfaguanidine	.5 gm.	-	-
A-6	Sulfaguanidine	.7 gm.	-	-
B-3	Dry skim milk	20.0 gm.	[1].05	-
B-4	Fish meal	20.0 gm.	[2].08 - 5.20	-

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TABLE 6.--Initial and final weights, average per fish, in grams

	Weights in lots														
	A-1	A-2	A-3	A-4	A-5	A-6	B-1a	B-1b	B-2a	B-2b	B-3	B-4	B-5a	B-5b	B-6
(S)	4.73	5.06	4.49	4.13	4.60	4.44	8.51	8.34	7.86	8.34	7.16	7.83	8.22	7.91	7.70
(E)	13.20	14.81	13.23	11.58	13.26	13.01	26.26	27.06	27.68	28.44	21.40	23.97	26.72	26.15	24.49
(I)	8.47	9.75	8.74	7.45	8.66	9.57	17.75	18.72	19.82	20.10	14.24	16.14	16.50	18.24	16.79

(S) - Start. (E) - End. (I) - Increase.

B-series. As the growth of lot B-3 was decidedly inferior to that of most of the B-groups which received a mixture of the two meals, it might be concluded that the two meals not only contained the identical growth factor but also supplemented each other. The writer would draw no such conclusion from the present data, however, because it was noticeable that the milk had a decided effect on the consistency of the feeds, diet B-3 being harder than any of the others. This difference may have affected food consumption.

Also consistent with the results of the first 16 weeks is the fact that neither the Aurofac nor the pure vitamin B_{12} induced in the A-diets a growth stimulus approaching that which was induced by the fish meal and the skim milk in the B-diets. Within the A-series, the Aurofac group again made somewhat better growth than the control group; this time the B_{12} group also made slightly better growth. The growth differential in favor of Aurofac over the control diet in the A-series was 36 percent during the first 16 and 13 percent during the second 16 weeks. Such differences, if statistically valid (the validity cannot be established from the present data), might seem important; but when they are compared with the growth obtained through the use of fish meal and skim milk, they are not impressive.

The data in table 6 show that the addition of vitamin B_{12} produced no better growth in the B-series than occurred without it. The Aurofac groups made somewhat better growth, as in the A-series, but when the results are subjected to statistical analysis, the increased growth of the Aurofac groups lacks just a little of being significant at the 5-percent level. If this test could be made with a far greater number of replications, it might reveal a statistically significant growth stimulus from the addition of Aurofac to the diet. The present data, though very limited, are against such an assumption.

The results from the addition of sulfaguanidine to the diet, in order to eliminate intestinal bacteria which might be synthesizing vitamin B_{12}, were disappointing. This procedure has been employed by a number of investigators. The short intestine of the trout would appear to be relatively unsuited for bacterial fermentation which might result in synthesis of vitamins, but the numerous duodenal caeca might exist chiefly for harboring just such bacterial synthesis. The growth data reveal no effect whatever from the inclusion of sulfaguanidine in the diet. This perhaps indicates, but does not prove, that trout do not get vitamin B_{12} from bacterial synthesis in the intestine.

TABLE 7.--Percentage of fish exhibiting anemia and blindness after 32 weeks on diet of meals

Lot number	Gill color			Lens color		
	Normal	Dark pink	Pink	Normal	Light	White
A-1	58	21	20	36	40	24
A-2	76	9	16	61	28	11
A-3	67	23	10	39	39	22
A-4	75	21	4	41	35	24
A-5	83	13	3	66	23	11
A-6	55	40	5	43	29	28
B-1a	99	1	0	96	3	1
B-2a	100	0	0	95	4	1
B-3	97	3	0	97	3	0
B-4	99	1	0	95	5	0
B-5a	99	1	0	92	7	1
B-6	100	0	0	94	5	1

At the conclusion of the experiment, the fish were examined for pathological lesions. These consisted of a certain degree of anemia in all lots of the A-series, and some degree of blindness present chiefly in the A-series but to a slight extent also in the B-series.

For estimating the anemia, the color of the gills was used as the criterion. In none of the fish was the anemia extreme. The data in table 7 show that anemia was present in all the A-lots but only to a slight degree in the B-lots. Within the A-series, the vitamin B_{12} group had the least anemia; but this was inconsistent with the fact that the Aurofac group was not one of the least anemic.

The abnormal eye condition consisted of some degree of whiteness or opacity of the lens in one or both eyes. The cornea appeared unaffected. Opaque lenses were dissected and proved abnormally soft and friable. Observations are presented on a percent basis in table 7. Blindness was present to some extent in all lots but was much more prevalent

in the A-series. Within the A-series, the groups getting the Aurofac and vitamin B_{12} had the least blindness; so there appears to have been a consistent benefit from the vitamin B_{12} in the supplement.

Summary

On a diet of vegetable meals, poor growth was obtained in brown trout. The fish became anemic and blind during the second 16-week period of these diets.

Both fish meal and dried skim milk contain a growth factor for trout. Both also contain factors which prevent anemia and help maintain normal eyes.

Vitamin B_{12} is not a growth factor for trout. The evidence that it affects the blood is inconclusive and contradictory. There is some evidence that it has an influence on the health of the lens of the eye, but this influence would appear to be indirect and subordinate to other factors.

A possible growth stimulus was obtained through use of a commercial feed supplement containing aureomycin and vitamin B_{12}. This stimulus was not quite significant at the 5-percent level, so was not statistically valid. If any true stimulus occurred, it would have to be attributed to the antibiotic or to other constituents of the supplement--not to the vitamin B_{12}.

An attempt to demonstrate need for vitamin B_{12} in trout by including a poorly absorbed sulfonamide in the diet was unsuccessful.

ACKNOWLEDGMENT

The vitamin B_{12} and the Aurofac used in these experiments were donated by the Lederle Laboratories. The Bi-Con APF-3 and Bi-Con TM-5 were donated by Chas. Pfizer and Company, Inc. A statistical analysis of the data reported in these experiments was kindly made by David C. Haskell of the Rome Hatchery.

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ASCORBIC ACID AND RHAMNOSIDES FROM SEA WATER

Efforts to identify the components of a substance that is physiologically active in oysters and that can be measured photometrically with n-ethyl carbazole, have been reported by P. J. Wangersky of the Fish and Wildlife Service.

The carbohydrates were removed from sea water onto a column of activated charcoal and then eluted from the column with ethanol. The two white crystalline compounds which remained after evaporation of the eluate were separated by their different solubilities in 50 percent ethanol. The substance (not yet identified) that precipitated in 50 percent ethanol gave some indication of being a rhamnoside.

Evaporation of the alcohol-water mixture produced a crystalline compound that, in water solution, gave an ultraviolet absorption spectrum similar to that reported for dehydroascorbic acid. A solution of dehydroascorbic acid was therefore prepared for comparative purposes by oxidizing ascorbic acid in the presence of copper ions in solution. Both in water and in 79 percent sulphuric acid, the absorption spectrum of this oxidation product closely resembled that of the compound from sea water. The same spectra were exhibited by the colors resulting from the reaction of the oxidized ascorbic acid and from the sample of sea water with 2,4-dinitrophenyldydrazine.

Absorption spectra from samples of sea water taken in various parts of the Gulf of Mexico and spectra run on oxidized ascorbic acid showed close agreement. From these curves it was concluded that the vitamin in sea water is largely in the form of dehydroascorbic acid. The amounts of vitamin indicated by the absorption spectra differed from the calculated amounts of carbohydrate found by the n-ethyl carbazole method. The discrepancy may result from the still unidentified "rhamnoside," which shows some color with n-ethyl carbazole. This "rhamnoside" is by far the most abundant carbohydrate in sea water. Concentrations as high as 0.1 gram to the liter have been found in inshore waters.

ABSORPTION OF RADIOACTIVE CALCIUM BY BROOK TROUT

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THE ROLE OF DISSOLVED MINERALS in trout nutrition has long been of interest not only to fish-culturists but also to fishery management workers. Because of the lack of necessary precision, it has never been possible to measure quantitatively by ordinary chemical methods the degree of utilization of dissolved minerals. The concept that fish can derive a portion of their nutrients from substances in solution in the water in which they live is credited to Pütter by McCay (1937). Krogh (1937, 1939) showed that fish selectively absorb inorganic salts from water and concentrate in their various tissues the elements of which these salts are composed. McCay and associates (1934, 1936) reported that much more calcium is taken from the water by brook trout than is provided in the diet.

Available data indicate that fresh-water fish do not swallow water, nor selectively absorb salts through their skin, but they do carry on salt exchange across the gills (Smith 1930, 1932). Schuster-Woldan (1936) reported that carp doubled their blood sugar when immersed in 1- to 5-percent glucose solutions for 15 minutes. This same author (1936) produced evidence indicating that carp actually drink solutions if the solutions contain nutrients. These experiments showed that when glucose and barium chloride were both present in the water, barium chloride could later be recovered in the stomach (by X-ray analysis). The presence of barium chloride alone in the water did not result in its recovery in the trout's stomach.

Prosser and associates (1945) reported that nonfeeding goldfish accumulated radioactive strontium, barium-lanthanum, and sodium from solutions in which they were immersed. Accumulation was rapid at first and continued at a rate greater than the loss of activity in the medium by decay and adsorption. Radioactive substances were shown to be taken up through the gill and oral membranes and distributed by the blood. When goldfish were transferred from radioactive to inactive water, the loss of activity from the body of the fish was slow.

Through a cooperative agreement with the Atomic Energy Commission, a program utilizing radioactive isotopes in nutrition studies on trout was put into operation in the summer of 1951. The experiments described in this report are preliminary. They were designed to ascertain if, and how much, radioactive calcium was absorbed by small, nonfeeding brook trout in a given period of time. Problems of general interest in these experiments included the rate of absorption, the site of greatest accumulation, and the rate of disappearance of any accumulated deposits.

At 55° F. and in water set in motion only by means of air under pressure for aeration, the survival time of brook trout is about 100 hours. Unless running water is used, metabolic products (toxic to trout) accumulate rapidly. In addition, radioactive solutions cannot be discarded haphazardly, as would be the case if the fish had been held in running water after exposure to radioactivity. A filtering device has been designed since the completion of this work, and it is hoped that future experiments may be continued for indefinite periods.

EXPERIMENTAL WORK

Small brook trout were held in running water in aquaria for about 60 hours after feeding. This resulted in almost complete elimination of food from the intestinal tract. The fish were then put in aerated stainless-steel aquaria (8 by 8 by 12 inches) in a temperature-controlled room (55° F.). Each aquarium was supplied with 4 liters of water, and 27 trout were placed in each aquarium.

In experiment 1, sufficient radioactive calcium chloride was added to the aquarium water to produce an activity of 5,000 counts per minute per milliliter. Similar experiments were then run in which the activity was increased to 10,000 counts per minute

to measure the effect of concentration upon the trout.

After periods of 1, 2, 4, 8, 12, 24, 48, and 72 hours, three fish were removed from the aquarium as quickly as possible and placed in 2 liters of distilled water for a few minutes to rinse off any adhering activity. The same net was used for each subsequent removal from the aquarium containing radioactive solution. A new net was then used to remove the trout from the distilled water, and both net and fish were rinsed with a stream of distilled water. After being killed, each fish was again rinsed and then weighed in a small porcelain evaporating dish.

These fish were dried under vacuum and then ashed in a muffle furnace. These fish are classified as whole fish in the tables that follow.

In experiment 2, to study the path of entrance and sites of accumulation of radioactivity, three additional fish were removed at the stated hours and dissected as follows: the gill arches were removed, weighed, and placed in a porcelain crucible; the gastrointestinal tract was removed and handled as above; and the remaining portions of the fish were placed in a third container. After each dissection, the instruments and rubber gloves of the worker were washed to remove any radioactive material. Each of these samples was then dried under vacuum and ashed in a muffle furnace.

Duplicate runs were made of all experiments, giving a total of six whole trout and six dissected trout to form the averages shown in the tables that follow.

The ash from each sample was dissolved in dilute hydrochloric acid (1:2) and filtered into a volumetric flask, from which suitable aliquots were taken for analysis and the measurement of radioactivity.

Total calcium was determined by a direct adaptation of the method described by Peters and Van Slyke (1931) for the determination of blood calcium.

To determine the radioactivity of each sample, aliquots equal in size to those used for the determination of total calcium were taken of the dissolved ash. The calcium was precipitated with ammonium oxalate and then washed with dilute ammonium hydroxide (1:49). The precipitated material was next dissolved in 1 or 2 milliliters of 0.2 N hydrochloric acid and made to volume with distilled water. The total volume was 3 or 4 milliliters, depending on size and activity of the sample.

One milliliter of this solution was evaporated to dryness under infrared rays in a metal cup. The activity was then measured by means of a thin-windowed Geiger-Müller tube. The activity, in terms of microcuries, corrected for self-absorption and decay, was calculated for each sample.

In an attempt to measure the length of time radioactive calcium remained in the body, trout were exposed to an initial activity of 5,000 counts per minute per milliliter of aquarium water for 48 hours. These fish were then transferred to an aquarium containing the same volume of water (4 liters) but having no activity. After periods of 1, 2, 4, 8, 24, and 48 hours, fish were removed and the parts analyzed as described previously.

In these experiments all differences in experimental data were established statistically by means of analysis of variance.

GENERAL DISCUSSION

The data for experiment 1 are shown in table 1 and plotted in figure 1. As shown by the activity, expressed in microcuries per gram of wet weight of fish, the rate of absorption of radioactive calcium by brook trout is greater during the first 12 hours of immersion than during the subsequent hours of the experiment. The rate was much greater than the loss of activity in the water through decay alone or through the adsorption of activity on the surface of the aquarium. The decay of calcium^{45} in 24 hours accounts for about 0.00007 microcuries. Between 10 and 20 times this activity per gram of fish is absorbed during the first hour of immersion in the radioactive solution.

Increasing the activity of the aquarium water to 10,000 counts per minute had no significant effect on the amount of radioactive calcium absorbed per gram of fish. This is in agreement with the findings of Prosser and his associates (1945). They reported that the amount of radioactive element absorbed by goldfish was independent of dosage in the range studied. In our experiments, and in the range of activity used, the amount of activity absorbed was also independent of the concentration of radioactive calcium in which the fish were immersed.

A summary of experiment 2, the distribution of radioactive calcium in the body of the trout, is shown in table 2 and figure 2.

The rate of accumulation of radioactive calcium in the various tissues of the trout body is rapid at first (first 12 hours), but this rate becomes slower with the passage of time. The same conditions are found for the absorption by the whole fish (figure 1). Initial activity of 5,000 or 10,000 counts per minute affects only slightly the amount

TABLE 1.--Absorption of radioactive calcium by brook trout

Immersion time in hours	Average wet weight of fish in grams (6 fish)	Microcuries per gram of fish (wet weight)
	5,000 counts per minute per milliliter	
1	6.7	0.00083
2	7.9	0.00191
4	5.9	0.00445
8	9.1	0.00686
12	7.8	0.01310
24	7.9	0.02120
48	7.5	0.04420
72	6.1	0.08440
	10,000 counts per minute per milliliter	
1	10.4	0.00120
2	7.9	0.00157
4	9.4	0.00455
8	6.1	0.00989
12	5.9	0.01140
24	7.9	0.02650
48	4.7	0.06210
72	5.4	0.06720

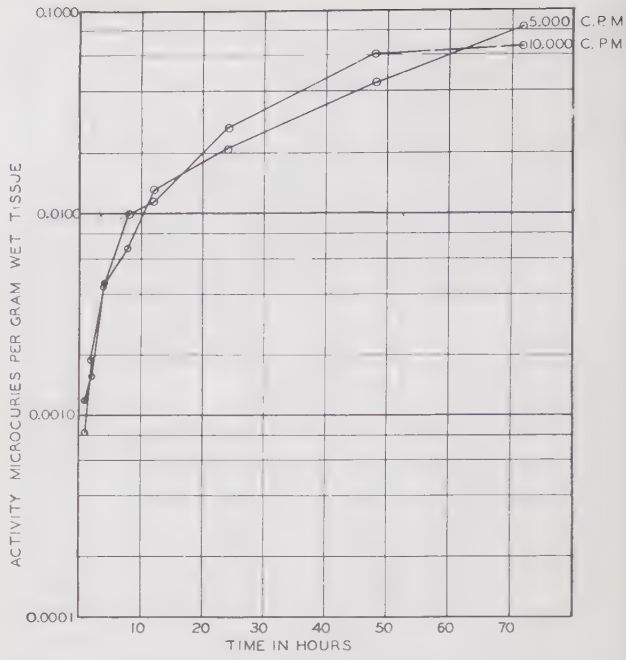

FIGURE 1.--Graphic description of absorption of radioactive calcium by brook trout.

of radioactivity absorbed per gram of wet tissue. The greatest difference in the effect of the initial dosage appears in the gastrointestinal tract of the trout.

The gill tissues accumulate the largest amount of active calcium per gram of tissue and the gastrointestinal tract (all viscera) accumulates the least in any given period of time. During the first 8 hours of the experimental period, there is little difference in the distribution of radioactive calcium between the gill tissues and the combination of muscle and skeletal parts (residue). The difference between these two samples becomes greater with time.

TABLE 2.--Summary of radioactive calcium absorbed by various parts of the trout body

Immersion time in hours	Average wet weight gill tissues (6 fish) in grams	Microcuries per gram of wet weight gill tissue	Average wet weight gastro-intestinal tract (6 fish) in grams	Microcuries per gram of tract, wet weight	Average wet weight of body residue (6 fish) in grams	Microcuries per gram of residue, wet weight
			5,000 counts per minute per milliliter			
1	0.167	0.00169	0.82	0.00074	5.1	0.00081
2	0.248	0.00262	0.98	0.00083	6.1	0.00162
4	0.290	0.00528	0.98	0.00175	6.6	0.00361
8	0.331	0.00994	1.19	0.00264	7.6	0.00674
12	0.250	0.02450	0.83	0.00433	5.3	0.01380
24	0.207	0.03380	0.56	0.00942	4.4	0.01820
48	0.236	0.05630	0.71	0.00633	5.7	0.02870
72	0.306	0.16600	1.15	0.01420	7.0	0.09760
			10,000 counts per minute per milliliter			
1	0.420	0.00242	1.26	0.00099	9.8	0.00088
2	0.328	0.00548	1.00	0.00144	7.3	0.00262
4	0.333	0.00527	1.13	0.00262	8.6	0.00582
8	0.310	0.01750	0.94	0.00375	7.2	0.00942
12	0.405	0.02270	1.11	0.00594	9.2	0.01190
24	0.388	0.05590	1.02	0.01800	8.4	0.02830
48	0.370	0.08020	0.83	0.01490	7.0	0.05520
72	0.290	0.12200	0.58	0.01560	5.7	0.09380

The results are similar to those reported by Prosser and his associates (1945), who used strong beta and gamma emitters in their work on goldfish.

The loss of radioactive calcium was practically nil during the 48-hour period of our observation. Some loss of activity occurred in the gastrointestinal tract, while the amount of radioactivity in the body residue and gill tissues remained almost constant. Prosser (1945) found that goldfish did not lose the major portion of their activity any faster than could be attributed to decay alone.

CONCLUSIONS

These preliminary experiments show that small nonfeeding brook trout do absorb calcium from the water in which they live. From the fact that the largest amount of active calcium per gram of tissue appears in the gills throughout the experimental period, it is concluded that the main path of entrance of calcium is through the gills. The fact that almost the same concentration of the radioactive calcium per gram of tissue is found in the muscle tissue and skeletal parts indicates that, after entering the body of the fish through the gill membranes, radioactive calcium is distributed through the body by the blood stream. Since radioactive calcium was found in those parts listed as the gastrointestinal tract, it should be recalled that these samples contained all of the internal organs and hence a considerable fraction of the circulatory system itself.

From these studies it becomes apparent that the fish need not necessarily rely on the food alone for some of the essential minerals. If calcium is absorbed, it is highly probable that other minerals may also be taken in; hence the chemical composition of the water itself assumes a role in supplying the needed minerals for the proper functioning of the trout's body.

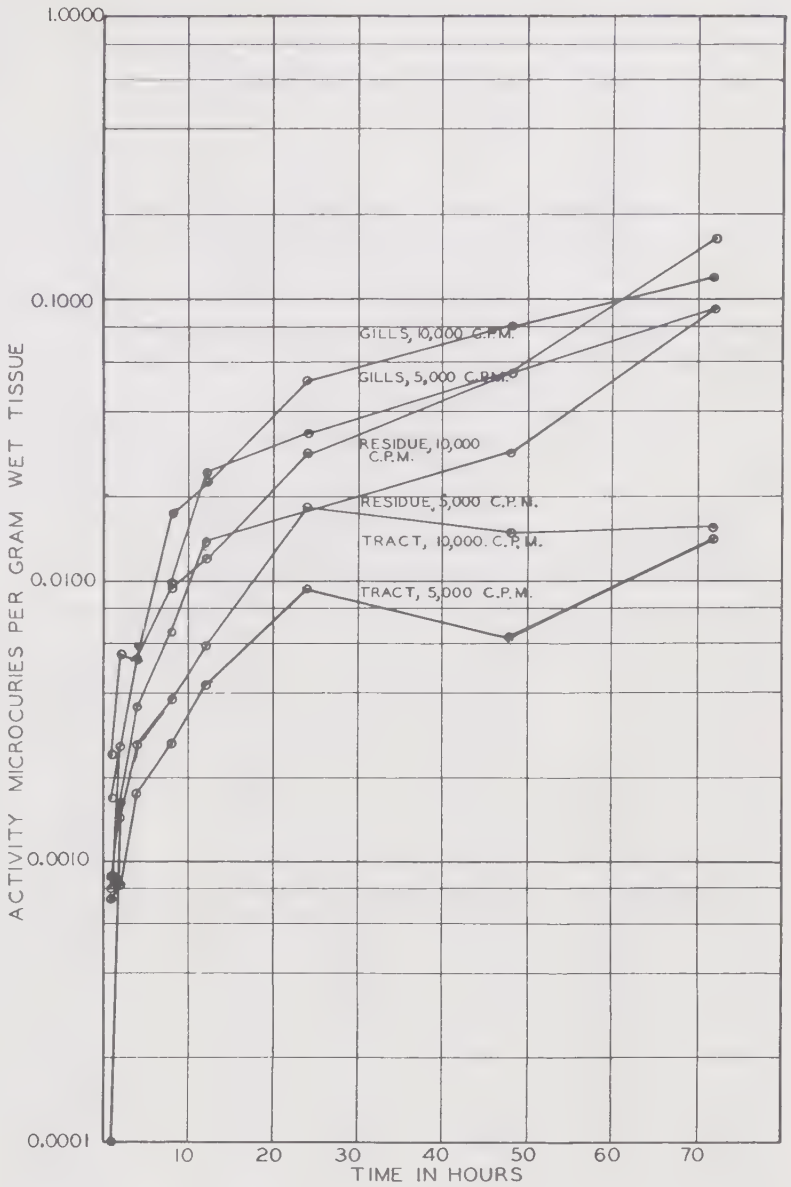

FIGURE 2.--Graphic summary of radioactive calcium absorbed by various parts of the trout body.

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FERTILIZATION EXPERIMENTS AT BARE LAKE, KODIAK ISLAND

Commercial nitrate and phosphate fertilizers have been applied at Bare Lake, Kodiak Island, during the summers of 1950 and 1951 in an attempt to determine whether fertilization of a fresh-water lake in Alaska will provide a practicable means of increasing the food supplies of the red (blueback) salmon. Preliminary work has recently been reported by P. R. Nelson of the Fish and Wildlife Service.

In July 1950, and again in July 1951, the lake received an application of approximately 6,500 pounds of sodium nitrate and 2,500 pounds of 19-percent superphosphate. The lake had previously been divided into 11 sections by means of shore markers and buoys, and approximately equal amounts of fertilizer were placed on the shore adjacent to the sections. Each of these stock piles was visited by a three-man crew using a rubber raft towed by a small skiff. The fertilizer for each section was mixed on the raft and then swept overboard while the raft was towed in a zig-zag course over the section.

Measurement of water transparency indicated a rather rapid increase in the phytoplankton populations. Before fertilization, the Secchi disc was visible at 6.8 meters in 1950 and at 6.1 meters in 1951; after fertilization, visibility declined to 2.4 and 1.8 meters.

In both years, though the water contained less than 1 p.p.m. of soluble phosphate and nitrate nitrogen before fertilization, samples of water taken the day after fertilization gave mean values of 7 p.p.m. of phosphate and 290 p.p.m. of nitrate. In 1950, phosphate was reduced to an unmeasurable amount in 12 days and nitrate in 17 days after fertilization. In 1951, phosphate was undetectable in the water 5 days after fertilization and nitrate had disappeared in 23 days. The greater amount of measured light early in the summer of 1951 may have caused the increased rate of removal of nutrients.

Measurement of rate of oxygen production by photosynthesis showed a sixfold increase occurring each year after fertilization.

Quantitative samples indicated a considerable increase in plankton populations after fertilization. In both years Ceratium, a photosynthetic phytoplankton that uses nitrate and phosphate directly, made a very large increase soon after fertilization. Larger non-photosynthetic plankton which serve directly as fish food showed increased reproductive capacities: thus the number of eggs per female of the most common group of rotifers more than doubled each year after fertilization, and the 1951 population of copepod offspring was much larger during the prefertilization period than in the previous year.

To evaluate the effects of fertilization upon fish production, data from several additional years will be required.

The School of Fisheries

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In 1913 MR. HUGH M. SMITH, at that time the U. S. Commissioner of Fisheries, suggested that a school should be established "to train fisherfolk" in more efficient methods of fishing and of handling and processing the catch. His plan probably resulted primarily from a trip he had made through Japan. That nation had grown to be the largest producer of fish in the world; and since fish was the principal source of protein in the Japanese diet, and a major item of foreign exchange, the industry was heavily subsidized by the government. Schools had been established to teach men how to fish and how to handle and process fish. Apparently Mr. Smith felt that these schools contributed materially to the preeminence of Japan as a fishing nation.

In the United States, agriculture had been subsidized through the founding of agricultural colleges in almost every State. These had been successful in developing more efficient farming methods and producing bigger crops; it was logical to assume that similar benefits would accrue to the fisheries industry from a fisheries college. This suggestion of a fisheries school was received enthusiastically in the growing Northwest, but World War I delayed its establishment. At the end of the war, the project was again taken up, this time by Mr. John N. Cobb, who had been an employee of the U. S. Bureau of Fisheries and later an editor of the trade magazine Pacific Fisherman, and the School of Fisheries was founded at the University of Washington in 1919, with Mr. Cobb as director. The original faculty consisted of Dr. D. R. Embody, later of Cornell University; Dr. Carl Fellers, now of Massachusetts State College; and Professor Trevor Kincaid. When the school was opened, the principal emphasis of its curriculum was on training in techniques of fishing and on the canning, salting, and processing of fish. Conservation was confined to training in systematic ichthyology and hatchery practices.

During the late 1920's the fisheries of the Northeast Pacific underwent a change. After a rapid expansion over the greater part of the range of the halibut in this area, unmistakable signs of growing scarcity of that species had become apparent. The International Fisheries Commission was set up to investigate the condition of the halibut fisheries and to determine what steps might be taken to prevent further decline and, if possible, to build up the stock. Other major fisheries in the area had begun to show that the supplies of fish were not inexhaustible, and conservation was being recognized as vital to the continued well-being of the fishing industry. With this change in the industry, a change in the objectives of the school was inevitable.

Dean Cobb died in 1929. In 1930, Dr. W. F. Thompson, at that time serving as director of the International Fisheries Commission, was made acting director of the School of Fisheries. Dr. Thompson had studied fishery biology under Drs. David Starr Jordan and C. H. Gilbert at Stanford University. His primary interest was in biology; under his leadership, all training in fishing and canning techniques was dropped and a new curriculum was adopted in the field of fishery biology and conservation.

The Northwest had become a center of a large fishing industry; thus, when the field of fishery conservation developed, it was natural that the Northwest should become a center for the agencies concerned with fishery biology and conservation. This circumstance was particularly favorable for the School of Fisheries, making it possible to supplement the formal training of the classroom with practical experience in fishery research. By 1940, five State, Federal, and international agencies had set up research staffs in Seattle, either on or near the University of Washington campus. These were the U. S. Fish and Wildlife Service, the Washington State Department of Fisheries and the State Department of Game, the International Fisheries Commission, and the International Pacific Salmon Fisheries Commission. The

successful work of the International Fisheries Commission in building up the halibut fisheries had by that time awakened the industry, as well as the conservation agencies, to the value of sound biological research. In 1941 the Applied Fisheries Laboratory, under the directorship of Dr. Lauren R. Donaldson, was established at the University of Washington by the Atomic Energy Commission.

During World War II the number of fishery students dwindled almost to zero; but, with the return of peace and the provision of government support for veterans attending college, the School was overwhelmed with men who, for the most part, were intensely interested in this field. In the meantime, the Alaska salmon industry, becoming concerned over the continued decline, or at least the uncertainty, of their catches, had contracted with the University of Washington for an independent investigation of the biology of the stocks. Dr. W. F. Thompson was placed in charge of this work, and he assembled a staff in the Fisheries Research Institute, as this group was named. The directorship of the School was taken over in September 1947 by Dr. W. M. Chapman, who, after a year spent in reorganizing the School, left to serve as Special Assistant in Fisheries to the Under Secretary of State in Washington, D. C. In September 1948, Dr. Richard Van Cleve had become acting director; in June 1951, upon the resignation of Dr. Chapman from the University, Dr. Van Cleve was named director.

Shortly after its establishment in 1919, the School of Fisheries was housed in four frame buildings which had served as officers' quarters, infirmary, and hostess house during the war. The School remained in these quarters for 31 years.

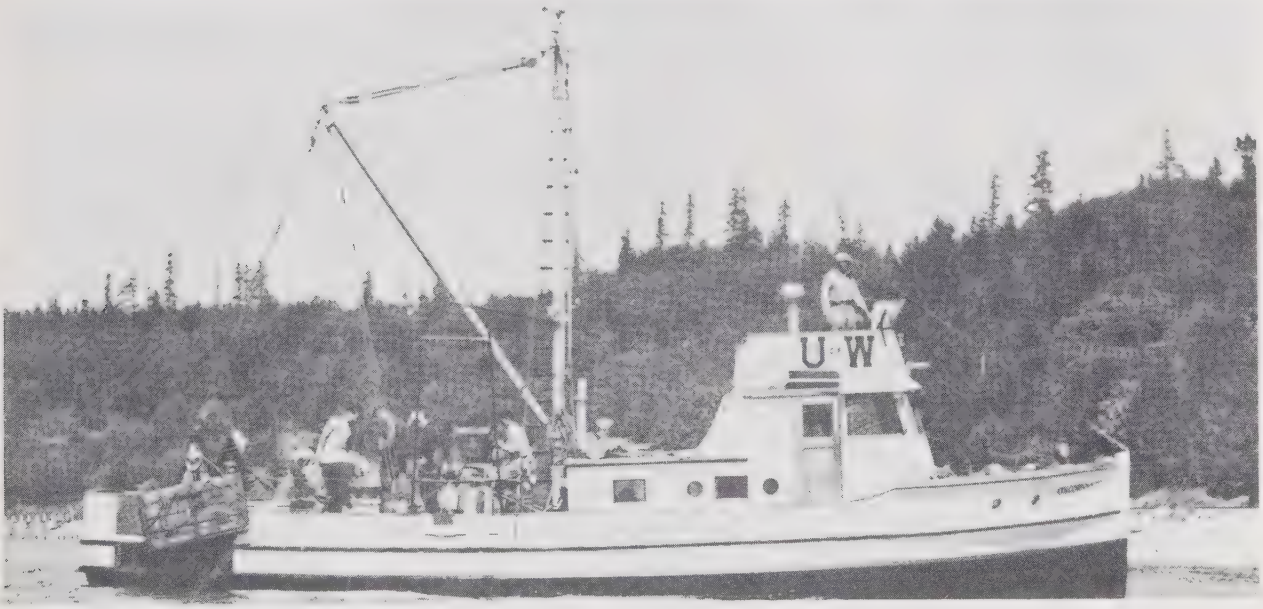
With the great increase in the number of students after World War II, the old buildings were so obviously inadequate that plans for a new building, held in abeyance for 10 years, were quickly completed and construction was started in the summer of 1949. By Autumn Quarter, 1950, the building was ready for classes and for the most critical research projects, and in November of that year the Fisheries Center was fully occupied and the dedication ceremonies were held. For the first time in its history, the School of Fisheries was housed in a good building which, when finally equipped, will furnish excellent facilities for both instruction and research.

In the interest of efficiency of construction and convenience of operation, similar functions were concentrated in various parts of the building. Fresh-water biology is provided with a 32-trough hatchery which also accommodates 14 tanks and 3 circular pools for rearing young trout and salmon. Five rectangular and two circular concrete pools are located within a wire enclosure on the lake side of the building. Running fresh water is pumped from Lake Union into the 18,000-gallon tank on top of the building to supply the hatchery and ponds. Supplementary emergency water can be diverted from the city water mains and can be dechlorinated in two large activated-carbon filters. Two other laboratories for fresh-water research are equipped with tanks and troughs. One laboratory is for the study of fish diseases and has its own sewage system. The other laboratory has thermo-regulated mixers in the water supply for constant-temperature work.

One disadvantage of the location of the School of Fisheries is its distance of about 5 miles from the nearest salt water. Therefore, the salt-water aquarium system was designed to be a self-contained unit, various features being borrowed from similarly situated aquaria in Chicago and San Francisco. Salt water, passing from one of two storage tanks, moves through a series of Pyrex glass coils where it is cooled by refrigerated brine circulating around the coils. Water from the other tank is warmed while passing through a thermostatically controlled heating coil. The warm and cold waters enter the aquarium room through separate pipes and provide a variety of temperatures when mixed in varying proportions. From the aquaria the water passes to the basement, where it is filtered and pumped back to the reservoirs on the roof, completing the circuit. The salt-water system is still in the process of development, with only one large and four small tanks now in operation.

One experiment under the joint supervision of Professors L. R. Donaldson and A. C. DeLacy has already shown results and promise of future development. In the spring of 1950, 26,000 silver salmon fingerlings, raised from eggs obtained from one of the Washington State fish hatcheries, were marked and released from the new hatchery ponds. Beginning in October 1951, 90 of these salmon have returned to the ponds at the School of Fisheries, traveling through the Government Locks, Lake Washington Ship Canal, Lake Union, and thence (via a fish ladder constructed by the School) into a large concrete holding pond. This number is considered an excellent percentage of return; and while this experiment is in no way unique, it does hold much promise for future experimentation with salmonoids.

The School of Fisheries from Portage Bay. The fish ladder through which returning silver salmon entered the outside ponds is in the foreground. The corner of the hatchery is behind the tree at the right. The technology laboratory is in the ground floor of the wing to the left. Student and faculty offices and research rooms occupy the remaining space on this side of the building.



The M. S. Oncorhynchus, a 50-foot diesel-powered boat belonging to the School of Fisheries and used for both classwork and research in Lake Washington and Puget Sound.

(Photographs courtesy of the author)

COLLECTION OF FISHES

A collection of fishes being accumulated for research now comprises around 250,000 specimens, involving about 1,500 species from the North Pacific and South Pacific Oceans and eastern and western North America. This collection contains many rare species with records of their distribution, as well as a few type specimens, and is available to advanced students, graduates, and ichthyologists from other institutions. Many of the fish have been brought back from the Marshall Islands by the staff of the Applied Fisheries Laboratory, and a large number were donated by Dr. A. W. Herre, Curator of Fishes at the School. Dr. W. M. Chapman donated many of the fishes collected by him in the South Pacific during World War II, and the School has received specimens from Australia and from the U. S. National Museum.

TECHNOLOGY

Several years ago plans were laid for again including fishery technology in the curriculum of the School of Fisheries. A lecture course was begun in the fall of 1945, and in Autumn Quarter 1948 a laboratory and lecture course with a full-time professor in fishery technology was instituted. This program attracted the interest of a number of graduate as well as undergraduate students. Additional formal training is planned; and with the expansion of graduate and faculty research, this field is expected to develop rapidly to a place of leadership, where material aid may be afforded in the solution of many of the problems now facing the industry.

CURRICULUM

Training in the School of Fisheries is designed to fit students for their chosen field of fishery biological research or technology, and is not intended to drill them in particular methods. Techniques in these fields are developing so rapidly that it would be useless to base a program entirely on the study of current methods. Basic principles of importance in developing new lines of research and new methods must be stressed in such a field.

Most students enter the School of Fisheries after 2 years of university preparation in the basic sciences of zoology, chemistry, and mathematics, with bacteriology and additional chemistry substituted for some zoology in the preliminary training of technologists. A course of lectures by leaders in fishery research organizations is given during this preparatory period to aid students in orienting themselves in fishery work. Background training in associated sciences is continued throughout the training.

The fishery curriculum follows a logical sequence, beginning in the student's third year of university work with a year of comparative anatomy, physiology, and the classification and identification of fishes. In addition, a year's course is offered in the classification, life history, distribution, and methods of cultivation or capture of commercial aquatic invertebrates. These two courses furnish the foundation upon which all subsequent study is built. More advanced students are offered a year of the general biology of fishes, including the study of the migration and interrelationships of fish populations; the reproduction, larval and postlarval life of marine fishes; and the relation of hydrographic conditions, food, etc., to the distribution, abundance, and availability of various species of fish. This is followed by a year's course in the mathematical phases of fishery biology, including the study of population growth and enumeration, population dynamics, and the influence of natural and artificial factors on variations in yield.

In fresh-water fishery biology, a year's course covers methods of hatching, rearing, collection, and incubation of salmonoids, and related problems; the nutrition of fishes;

(Opposite page)

(1) Rearing and holding facilities at back of School of Fisheries building. Fish ladder is at right.

(2) Disease room, in which lake or dechlorinated domestic water (at temperatures regulated by heater or refrigeration system) is available for 15 troughs.

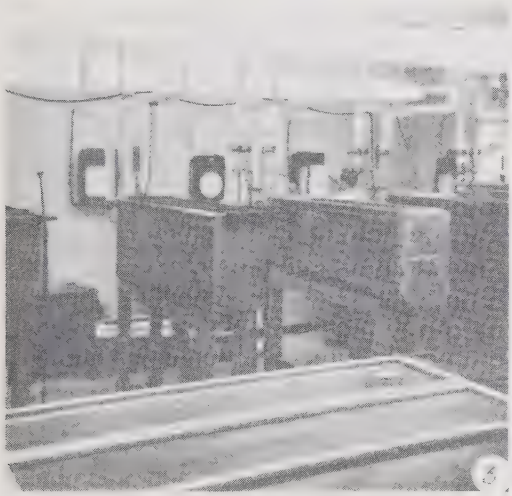
(3) Constant-temperature room, where six tanks and four troughs receive cooled or warmed water.

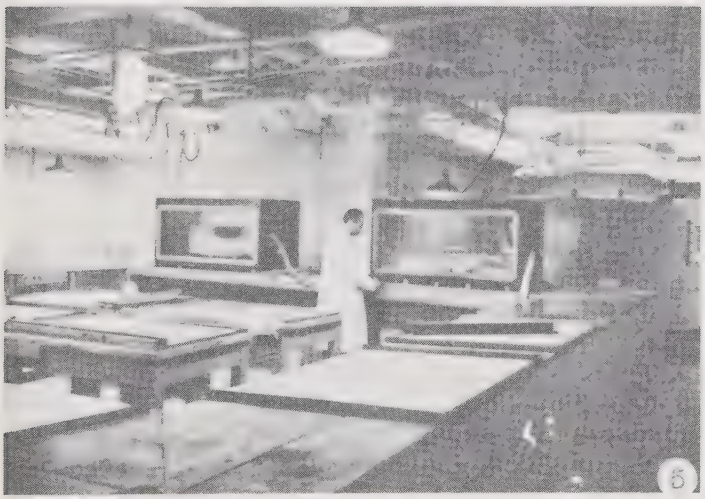
(4) Hatchery room, equipped with 18 concrete and 14 wood troughs, 3 circular and 14 rectangular tanks, and drip incubator. The troughs in foreground have drains in each section to allow flushing when eggs are being reared in silt-laden water.

(5) Salt-water area, now under construction, will have 23 tanks in which water temperature can be varied between 40° and 80° F. in two separate closed systems. Tank in background has 10-foot diameter, 5-foot depth of water, and 12 observation ports.

(6) Bacteriology laboratory, equipped for study of fish tolerance for chemicals.

(Photographs courtesy of R. R. Rucker, Fish and Wildlife Service.)





Facilities used by the Fish and Wildlife Service in Western Fish Disease Investigations at the University of Washington

and finally, problems of management of freshwater fisheries. This is supplemented by a course in communicable diseases of fish.

As already noted, courses in fishery technology have been added to the curriculum to meet the needs of the industry. At present a year's course covers the application of chemistry, biology, and engineering to the canning, curing, and freezing of fish and shellfish, and to the preparation of fish byproducts, oils, meals, etc. Another course extending through fall and winter quarters comprises lectures by authorities in various fields of the fishing industry. The latest machinery is being obtained for experimental work in technology: canning machinery has been lent to the School of Fisheries by American Can Company and Anchor Hocking Glass Company. As equipment and facilities are added, further technological training of a more advanced character will be offered. Much emphasis is placed upon the study of current literature in all fields of fishery research and technology, and every student of technology--as well as of biology--is required to participate in three quarters of seminars devoted to a study of the literature and the preparation of talks.

With well-equipped chemical and bacteriological laboratories and a modern freezer and cold-storage room, technological research will become possible under almost ideal conditions. Such equipment will make it possible for faculty and students to supplement the work of fishery agencies by undertaking the investigation of problems usually considered outside the field of operations of conservation agencies or the industry--but whose solutions are essential to a final understanding of fishery biology and technology.

The research program of the School of Fisheries is probably unique in that most of the student problems form a part of the programs of fishery conservation organizations in the Northwest. Many of the theses written by graduate students in attaining higher degrees are results of practical investigations conducted by professional biologists and brought back to the School. This merger of the work of the School with that of the conservation and research agencies has been fortunate indeed, since it has made available to students the use of research equipment and facilities which the School lacks. Also, the practical aspects of the work and their influence on the thinking of the faculty have kept the scholastic objectives clear. In addition to this type of research, carried out often in other laboratories, ample room and equipment for graduate study and research is provided for the first time in the School's history at the new Fisheries Center. Marine fishery research is built around a study of the fishes of Puget Sound, carried out with a 50-foot diesel boat of purse-seine design which has been in operation since 1948. This vessel furnishes collecting and sampling facilities which make the entire Puget Sound area our laboratory. Unlimited possibilities are thus presented for the study of the life history, distribution, and relationships between the populations of Puget Sound fishes and their natural environment. Instruction and research in these fields are being aided and extended by the experimental facilities of the salt-water aquaria within the new building.

It must be recognized that, to remain effective, the School of Fisheries must maintain the closest contact with the biological research and conservation agencies on the one hand and industry on the other. Seasonal work with research staffs that are developing the foundations for conservation, together with experience with agencies actually regulating sport and commercial fisheries, provides training for which there is no substitute. Both research agencies and industry benefit from the availability for summer work of a group of men who have at least a theoretical background for specialized fishery field work, and who will later provide a source of well-trained permanent employees.

As the field of fishery conservation develops, the need for a more profound understanding of the related sciences becomes more evident. Students must now carry as much work as possible in chemistry, biology, and mathematics or related fields of physics, engineering, and economics, according to their individual interests and abilities. The recent increase in the number of graduate students (49 this year) is therefore encouraging, as these men generally specialize even further in these related subjects. Future progress in all fields of fisheries will depend on broader understanding of the basic sciences and ability to apply this understanding to fishery conservation and technology.

The 1868 report of the U. S. Commissioner of Agriculture gave 29 pages to fish culture.

A NOTE ON EXPERIMENTS DESIGNED TO TEST THE VIABILITY OF GAMETES AND THE FERTILIZATION OF EGGS BY MINUTE QUANTITIES OF SPERM

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DURING THE TROUT SPAWNING SEASON of 1950-1951, an experimental study was initiated to test the viability of eggs and sperm after removal from the fish and also to measure the quantity of sperm necessary for fertilization.

A simple experimental design was drawn up, wherein, unlike some other investigations (Neresheimer 1937, Smith and Quistorff 1943, Butcher 1944, Rucker 1949, Barrett 1951, and others), special precautions in handling the gametes were deliberately avoided except where it was necessary to measure the gametes or to keep them separate. Because this study was incidental to the chief research program on selection and hybridization, the proper amount of time and care could not be allowed; but the results obtained, though incomplete, suggest the possibility of savings in fish-hatchery man hours and expense. The research program at Madison does not allow time for a continuation of this phase of research; so the plan and data are presented in the hope that others will repeat the experiment with the care it deserves.

VIABILITY OF GAMETES - EGGS

Eggs of rainbow trout (Salmo gairdnerii) and brown trout (S. trutta) were tested. The eggs were expressed into dry 200-cc. beakers at given time intervals (10, 20, 30, 40, 50, 60, 75, and 90 minutes) before fertilization during the normal spawning operations at the Nevin State Fish Hatchery, Madison, Wisconsin. The full complement of eggs was taken from whichever fish the hatcherymen were handling at the predetermined time. Each lot was set aside in its beaker to stand until the time series was complete, when all egg lots in the series were fertilized with the same sperm, a mixture from several males. Before fertilization, the beakers stood uncovered in the air, the eggs kept only in the ovarian or coelomic fluid that had been expressed from the females with the eggs. During the period of these experiments, the air temperature varied little from the water temperature of the raceways. (Air temperature, 8° to 15° C.; water temperature, 9.5° to 11° C.)

Fertilized survivors were counted at hatching. The results are listed in table 1 and graphically represented in figure 1. It is to be noted that two of the seven runs terminated at 60 minutes.

VIABILITY OF GAMETES - SPERM

Sperm viability was tested in two series. Brown trout sperm was expressed into dry 50-cc. beakers (one fish per beaker) and held in the same manner as the eggs for 15, 25, 35, 45, 60, and 75 minutes for each series. When the sperm had been held for the required periods, the different lots were added to separate lots of eggs, which came from a mixture of eggs taken fresh from a number of females.

Results were inconclusive. Mortality was high in all instances. One series had 100 percent mortality in three of the six lots. The second series gave the following results:

Length of time before sperm used (minutes)	15	25	35	45	60	75
Percentage survival of eggs to hatching	34.0	27.7	51.0	71.6	32.2	43.0

This study was supported by a fund from the Wisconsin Conservation Department and administered by the University of Wisconsin Research Committee.--The EDITORS.

TABLE 1.--Viability of eggs fertilized at 10-minute intervals after stripping

Group		Time before fertilization (minutes)							
		10	20	30	40	50	60	75	90
Brown trout I	Mortality to hatching	59	48	257	261	87	126	-	-
	Number eggs hatching	939	585	740	413	427	712	-	-
	Total number eggs	998	633	997	674	514	838	-	-
	Percentage survival	94.0	92.5	74.2	61.3	83.0	85.1	-	-
Brown trout II	Mortality to hatching	16	41	77	63	27	68	-	-
	Number eggs hatching	585	663	660	638	499	541	-	-
	Total number eggs	601	704	737	701	526	609	-	-
	Percentage survival	97.2	94.1	89.6	91.0	94.8	89.0	-	-
Brown trout III	Mortality to hatching	1	34	33	97	32	49	42	107
	Number eggs hatching	430	328	356	239	343	418	246	82
	Total number eggs	431	362	389	336	375	467	288	189
	Percentage survival	99.7	90.6	91.5	71.1	91.5	89.5	85.5	43.4
Brown trout IV	Mortality to hatching	62	22	229	69	13	85	70	95
	Number eggs hatching	309	361	190	288	388	401	339	579
	Total number eggs	371	383	419	357	401	486	409	674
	Percentage survival	83.3	94.2	45.5	80.7	96.8	82.5	83.0	85.9
Brown trout V	Mortality to hatching	280	80	30	106	127	241	178	53
	Number eggs hatching	114	290	338	360	222	183	459	548
	Total number eggs	394	370	368	466	349	424	637	601
	Percentage survival	29.0	78.5	92.0	77.2	63.6	43.2	72.0	91.0
Rainbow trout I	Mortality to hatching	10	87	100	392	57	311	63	28
	Number eggs hatching	306	611	355	124	585	155	267	337
	Total number eggs	316	698	455	516	642	466	330	365
	Percentage survival	96.9	87.7	78.1	24.0	91.0	33.1	81.0	92.4
Rainbow trout II	Mortality to hatching	7	(1/)	172	28	210	67	62	41
	Number eggs hatching	268	(1/)	44	448	77	328	301	497
	Total number eggs	275	(1/)	216	476	287	395	363	538
	Percentage survival	97.5	(1/)	20.2	94.1	26.8	83.0	83.0	92.4

1/ All eggs infertile.

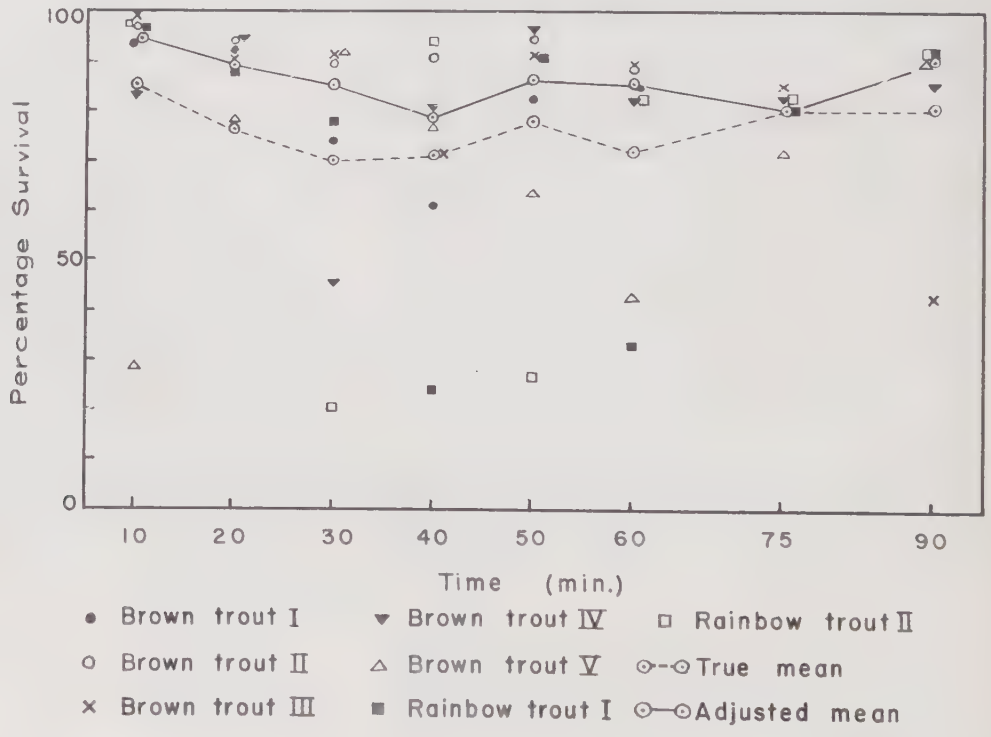

FIGURE 1.--Survival of eggs that were held for different periods before fertilization. The true mean includes all data; the adjusted mean neglects egg lots in which survival was less than 60 percent.

FERTILIZATION OF EGGS BY MINUTE QUANTITIES OF SPERM

Tests were made with brown and rainbow trout, two runs for brown and one for rainbow. For each run the eggs of four or five females were mixed together to minimize individual differences and then were divided into five approximately equal lots for fertilization. Sperm were taken from three or four males and mixed. A different aliquot of this sperm was added to each of the lots of eggs of the particular run. The quantities of sperm, measured by 1-cc. pipette, were 1 cc., 0.5 cc., 0.25 cc., 0.12 cc., and 0.06 cc. The egg-sperm mixture was thoroughly stirred before water was added for hardening. The fertilized survivors were counted at hatching.

The results of these runs are listed in table 2 and are graphically represented in figure 2.

TABLE 2.--Fertilization of eggs by minute amounts of sperm

Group		Quantity of sperm (cc.)				
		1.0	0.5	0.25	0.12	0.06
Brown trout I	Mortality to hatching	423	634	528	313	658
	Number eggs hatching	508	645	886	1,580	777
	Total number eggs	931	1,279	1,414	1,893	1,435
	Percentage survival	54.5	50.4	62.6	83.5	54.2
Brown trout II	Mortality to hatching	192	137	156	242	229
	Number eggs hatching	1,305	1,740	1,715	1,509	1,705
	Total number eggs	1,497	1,877	1,871	1,751	1,934
	Percentage survival	87.2	92.7	91.7	86.2	88.2
Rainbow trout	Mortality to hatching	134	350	457	484	661
	Number eggs hatching	584	1,274	1,052	1,037	778
	Total number eggs	718	1,624	1,509	1,521	1,439
	Percentage survival	81.2	78.5	69.9	68.1	54.1

CONCLUSIONS

The given figures suggest that eggs of trout can be held, with no special precautions, for considerable periods without losing their fertility. There is also evidence that minute quantities of sperm can fertilize large numbers of eggs. The figures presented include greater mortalities than are generally encountered in hatchery operations: these figures represent total mortality, i.e., dead fertilized eggs as well as unfertilized eggs. The former predominate and are the result of unfavorable conditions during the time of development. The mortalities are sufficiently randomized not to bias the results, but the presence of the mortalities makes it imperative that the experiments be repeated. What is important is not the absolute magnitude of the mortalities but the relative magnitude, which is best shown by the constancy of the level of mean percentage survival in all the groups (figures 1 and 2).

APPLICATION OF RESULTS

A female trout produces, on the average, about 1,500 eggs. Mature males at the Nevin State Fish Hatchery average slightly more than 3.5 cc. of sperm per stripping. Table 2 shows clearly that 0.12 cc. of sperm is more than sufficient to fertilize 1,500 eggs. One male producing 3.0 cc. of sperm will supply 24 aliquots of 0.12 cc. at a single stripping. Or, one male can fertilize the eggs from 24 females. These calculations leave a good

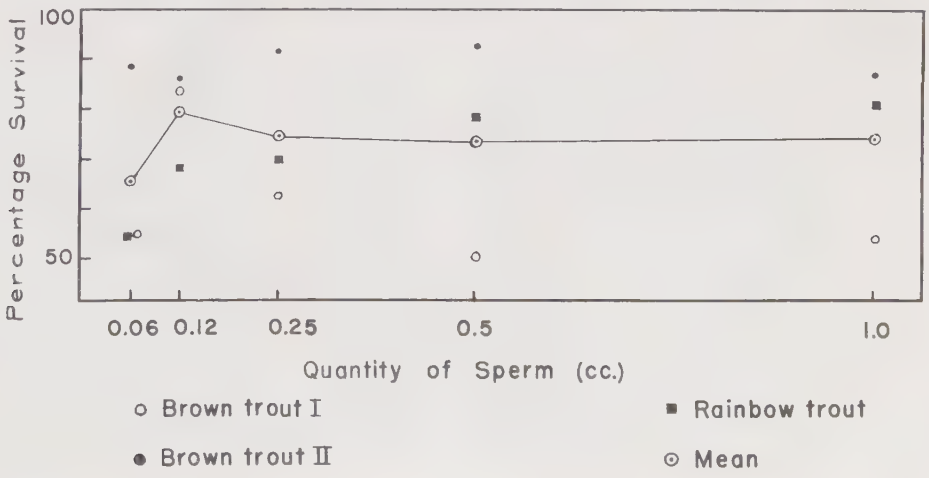

FIGURE 2.--

Survival of eggs that were fertilized with different quantities of sperm.

margin of safety. To improve this, it is here suggested that a ratio of 10 females to 1 male might prove practicable. Wood and Dunn (1948) also have suggested the possibility of a ratio of this size. Because of the length of life of the egg, it is possible to select 10 females, express the eggs from them, and still take time to select quality males. The only requirements are that the "dry" method of egg-taking be used and that the eggs and sperm be well mixed.

If a ratio of 1 male to 10 females can be maintained practicably in the brood stock of a fish hatchery, it means that in most establishments from 30 percent to 45 percent of the brood stock may be disposed of, with a resultant decrease in the expense and time consumption of feeding the stock, as well as alleviation of crowded conditions where they occur. Or, more female stock may be kept in the space occupied by the males; hence a greater production will be possible. Because eggs remain fertile for at least 30 minutes after stripping, ample time would be available for rigid selection of parental fish.

ACKNOWLEDGMENT

Grateful acknowledgment is extended to Mr. Wendel Anderson and his staff at the Nevin State Fish Hatchery for fine co-operation during all phases of the work.

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SCALE STUDIES OF THE LAKE TROUT ON THE GREAT LAKES

Characteristics of lake trout scales have offered some difficulties in the development of a technique for determining ages in this species as a prerequisite to the investigations of the Fish and Wildlife Service on the Great Lakes.

The scale laid down by the lake trout in the first year is often very indistinct and small, showing only a few crowded and broken circuli. For consistent data, it apparently must be assumed that the "central checks" are true annuli, regardless of the small size of the computations.

A lake trout annulus may easily be overlooked. A break and an approximation of as few as two circuli may represent an annulus. Frequently, the boundary of an annulus is indicated by a whorled circulus rather than by a single continuous circulus, so that it is difficult to determine exactly the limits of retarded growth in the anterior and posterior fields used for scale measurements. In later years an annulus may sometimes be indicated by an area of indefinite, broken circuli in the anterior field. Further, there may be considerable variation in the distinctness of annuli on scales of different sizes and shapes from the same fish.

The technique for determining the age of lake trout requires information not only on the date of collection but also on the size of the fish. Also necessary is the mounting of perhaps a dozen scales of different sizes and shapes. Moreover, the great variability in the length of trout of the same age makes it necessary to calculate the length for each year of individual fish in order to check the reasonableness of the interpretation of an annulus with respect to its location on a scale.

A COMPARATIVE MORPHOLOGIC AND PHYSIOLOGIC STUDY OF FISH BLOOD

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Carbondale, Illinois

THERE IS A LACK OF INFORMATION concerning the morphologic and physiologic characteristics of the blood of different fishes. The work to date is largely represented by the reports discussed below.

Marsh (1902) showed that the erythrocytes vary among the different species of trout. Bonnet (1929) found that the erythrocyte count of different species of fishes increased when the fishes were held in waters of low oxygen content. Wintrobe (1933), in his study of several marine teleosts, found that although the erythrocyte count varied, the hemoglobin within the cell remained constant. Malassez (1872) found in teleosts that the fishes which had the higher counts had the smaller cells, whereas the fishes with the smaller counts had the larger erythrocytes.

The present investigation was aimed at obtaining more quantitative data relevant to the morphological and physiological consideration of the blood of some of the more common warm-water fishes.

MATERIALS AND METHODS

The species considered in this investigation were:

Ictiobus bubalus (Rafinesque)--------Smallmouth buffalo
Carassius auratus (Linnaeus)-------------------Goldfish
Cyprinus carpio Linnaeus--------------------------Carp
Ameiurus natalis (LeSueur)--------------Yellow bullhead
Ameiurus melas (Rafinesque)--------------Black bullhead
Minytrema melanops (Rafinesque)----------Spotted sucker
Micropterus salmoides (Lacepede)--Largemouth black bass
Lepomis macrochirus Rafinesque-----------------Bluegill
Chaenobryttus coronarius (Bartram)-------------Warmouth
Pomoxis annularis Rafinesque--------------White crappie

These fishes were collected from different locations in the vicinity of Carbondale, Illinois. The goldfish were taken from a small pond located on the campus of Southern Illinois University. The bluegill, white crappie, black bullhead, yellow bullhead, warmouth, largemouth black bass, and spotted sucker were taken from Little Grassy Lake. The carp and smallmouth buffalo were taken from the Big Muddy River.

All the fishes collected were taken in traps or nets. They were kept in holding tanks in which the oxygen levels were maintained by a small, compressor-type aerator. The oxygen content was checked daily and kept in a range of 6 to 8 p.p.m. After the fish had been in the tanks 3 or 4 days, samples of blood were taken from the gill arches. These samples were checked for clotting time, hemoglobin content, erythrocyte counts, and morphology of the erythrocytes as seen in smears.

The clotting time of the blood was determined by use of small glass capillary tubes. The clotting time was considered to be the interval starting when an incision was made and terminating when the blood came out of the tube in "strings." The hemoglobin content was determined by the Sahli method. The erythrocyte counts were made by drawing blood from the incision of the gills into a pipette and diluting 1:200 with Hayem's solution. Counts were made by use of a microscope and a Spencer hemocytometer. Mean values were determined for the hemoglobin percentages, clotting times, and erythrocyte counts for each species. A standard of 17.5 grams was used to compute the hemoglobin percentages (table 1).

The sizes of the erythrocytes and of the erythrocyte nuclei were determined by means of an ocular

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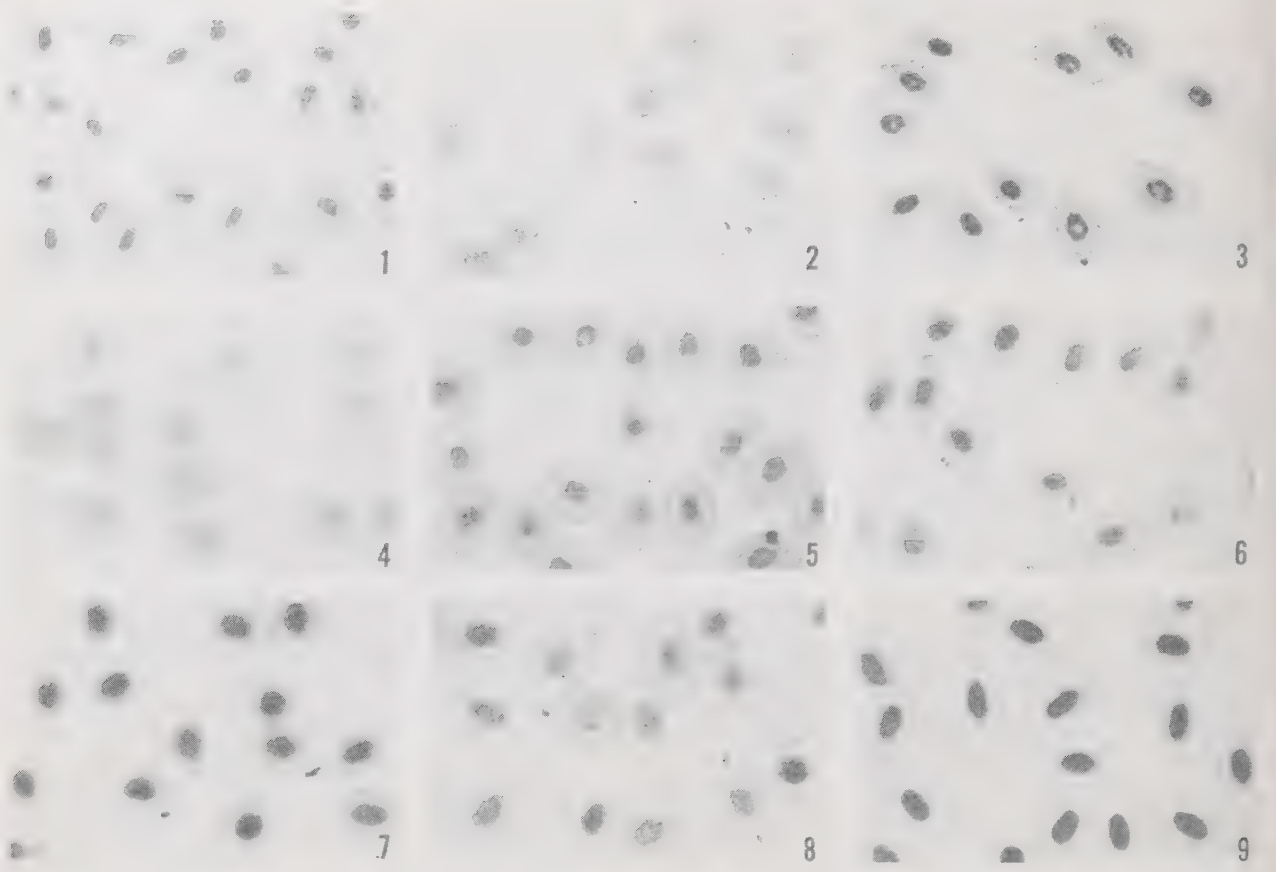

FIGURE 1.--Erythrocytes of the bluegill (1), warmouth (2), largemouth black bass (3), white crappie (4), black bullhead (5), goldfish (6), carp (7), spotted sucker (8), and smallmouth buffalo (9). All photographs made at the same magnification under oil immersion lens 970X.
(Courtesy of the authors)

micrometer. Ten cells were chosen at random from a typical blood smear of each species, and 10 readings were made on the length and width of both the erythrocytes and their nuclei. Mean values were determined from these measurements. Photomicrographs of typical blood smears for each species were made to facilitate comparison of the erythrocytes as to relative sizes and other morphological characteristics. All photographs were made at a magnification of 970X with an oil immersion lens.

TABLE 1.--A comparison of the erythrocyte counts, hemoglobin content, and clotting time of several species of fishes

Species	Number of fish	Red blood cells per cu. mm.	S. D.	Hemoglobin content in percent	S. D.	Mean corpuscular hemoglobin in micromicrograms	Clotting time in seconds	S. D.
Lepomis macrochirus	27	2,605,555	± 654,670	45.2	± 9.7	29.4	29.6	± 8.4
Pomoxis annularis	12	1,795,000	± 687,222	48.7	± 5.4	46.7	23.1	± 2.9
Chaenobryttus coronarius	3	1,880,000	± 477,703	38.0		34.0	26.8	± 6.3
Ameiurus melas	14	1,610,000	± 475,426	55.6	± 8.9	58.4	37.3	± 3.3
Ameiurus natalis	11	1,490,000	± 488,000	55.6	± 9.3	62.3	41.5	± 16.5
Ictiobus bubalus	4	1,332,000	± 88,988	40.0	± 6.0	52.3	41.3	± 2.6
Cyprinus carpio	2	1,310,000	± 1,950	42.0		54.9	35.0	
Carassius auratus	19	1,240,000	± 466,120	30.4	± 13.7	41.1	10.8	± 1.8
Minytrema melanops	2	1,220,000	± 240,416	61.0	± 1.0	84.5	27.5	± 2.5

RESULTS

Definite variations between species were detected in all the morphologic and physiologic factors considered. The erythrocyte counts ranged from 1,220,000 to the cubic millimeter for spotted sucker to 2,605,555 to the cubic millimeter for bluegill. (See table 1.)

The highest hemoglobin percentage was 61 percent for spotted sucker. The other hemoglobin values ranged downward. The lowest was 30 percent, which was recorded for goldfish. (See table 1.)

The clotting time did not vary to a great extent among the different species. The highest clotting time was 41 seconds for both yellow bullhead and smallmouth buffalo. The other clotting times were of the same magnitude except for that of goldfish, which was only 10 seconds. (See table 1.)

There were definite variations in the morphology of the erythrocytes from the different species. The shape, as well as the relative size, of the cells varied markedly. Some species, such as goldfish, smallmouth buffalo, and spotted suckers (figure 1: 6, 8, and 2), were found to have oval-shaped cells. Other species, such as yellow bullhead and black bullhead, had cells that were almost round in shape (figure 1: 5). Warmouth and largemouth black bass exhibited cells that were oblong and somewhat pointed at each end (figure 1: 2 and 3).

As regards the size of erythrocytes, the longest were of the oval type from smallmouth buffalo. Their mean length was 15.3 microns, whereas the bluegill cells measured only 10.9 microns. (See table 2.) The cell widths appeared in somewhat the same order as the cell lengths, except that the greatest widths were exhibited by the cells of European carp and yellow bullheads. The smallest cell width was characteristic of bluegill (figure 1: 1).

The largest nuclei were also in the same order as the erythrocyte size and appeared to take the same shape as the cell in which they were found.

TABLE 2.--A comparison in size of the erythrocyte length and width, and of the nucleus length and width, in microns, of several species of fishes

Species	Cell length[1]	S. D.	Cell width[1]	S. D.	Nucleus length[1]	S. D.	Nucleus width[1]	S. D.
Ictiobus bubalus	15.3	1.0	9.0	1.2	4.9	0.6	4.7	1.0
Minytrema melanops	14.0	1.1	9.1	1.2	6.2	.5	4.3	.4
Cyprinus carpio	13.4	.5	10.2	1.0	5.9	.9	4.4	.4
Carassius auratus	13.3	1.2	8.0	.5	5.5	.5	3.3	.4
Ameiurus natalis	12.4	.9	10.5	.8	4.9	.8	3.9	.5
Pomoxis annularis	11.8	1.6	7.2	1.0	4.4	.5	3.2	.5
Micropterus salmoides	12.1	1.1	6.8	.7	5.8	1.0	3.1	.5
Chaenobryttus coronarius	11.1	1.7	7.7	.5	4.7	.6	4.1	.4
Lepomis macrochirus	10.9	.9	6.4	.9	4.9	1.1	2.6	.4

[1] These are mean values obtained from the measurement of 10 cells all from the same specimen.

DISCUSSION

The average red blood cell counts of the different species of fishes considered vary rather markedly. Comparing the red blood count (table 1) with cell size (table 2), it is apparent that there is a correlation between cell count and cell size, i.e., the smaller the cells, the higher the count. As stated in the review of literature, Malassez (1872) also observed this correlation. Other than this correlation, the exact significance of the variations in red blood count and cell size and the variations in hemoglobin content and clotting time is not understood. It would be of value to determine whether any relationship exists between these variables and the low oxygen tolerance of different species of fishes. Unfortunately, our knowledge of the variation in low tolerance and of the variations in the nature of the blood is not adequate to make a good comparison.

CONCLUSIONS

1. There is a pronounced variation, species to species, in the red blood count, size of red blood cells, hemoglobin content, and clotting time of bluegill, white crappie, warmouth, black bullhead, yellow bullhead, smallmouth buffalo, European carp, goldfish, and spotted sucker.

2. There is a correlation between size of the blood cells and the red blood cell count. Species having relatively small cells had relatively high counts, whereas species

with relatively large cells had relatively low counts.

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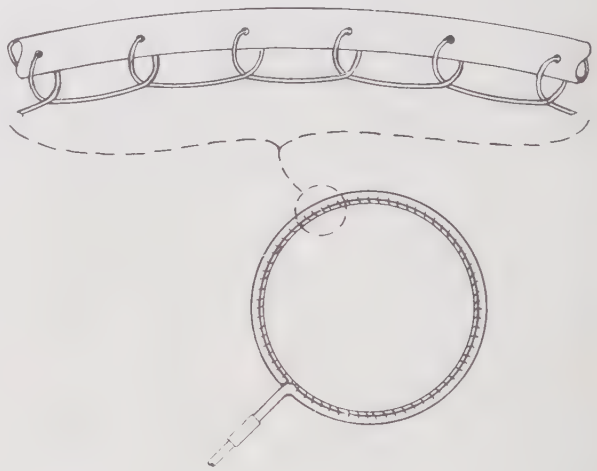
AN IMPROVED DIP NET

A dip net that apparently requires little maintenance is described by Frank A. Stefanich of the Montana State Fish and Game Department.

The first essential is an electric drill and several 1/8-inch bits. Steel airplane tubing 5/8 inch in diameter and 6 feet long is sufficient for the hoop and for the attachment of the handle. About 8 feet of annealed steel wire, size 14, will be needed for making loops. A handle such as may be used on a garden rake or hoe is suitable.

The first step is to bend the tubing into a hoop about 18 inches in diameter. One end is then welded to the side of the tubing, and the remainder is bent to receive the handle. Holes 1/8 inch in diameter and 1-1/4 inches apart are drilled through the tubing, slightly inside the center of the pipe. The wire is next put through these holes, being passed under itself each time so as to make a series of loops. A dip net bag may then be threaded to the wire with any kind of cord. This type of construction allows the bag to be reversed.



The problem of destroying lamprey larvae without harming fishes in the same waters, has led to the testing of hundreds of compounds. Used at relatively low concentrations in test aquaria, several compounds have killed lamprey larvae without injuring goldfish. The next step is to test for selectivity with respect to other fishes and associated food organisms.

ERROR: The April egg take of a newly established brood stock of cutthroat trout at the Fish and Wildlife Service's Creston (Montana) Station totaled 250 thousand, instead of the 250 million reported in the July issue (page 109) of The Progressive Fish-Culturist.

WALLEYED PIKE FINGERLING PRODUCTION IN DRAINABLE CONSTRUCTED PONDS IN MINNESOTA

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DURING THE PAST 13 YEARS the Minnesota Department of Conservation has raised walleyed pike from fry to fingerling size in ponds. Two types of ponds have been used: (1) artificial ponds so constructed that they can be drained, and (2) shallow natural ponds from which the fingerlings are harvested by seining. This report deals with fingerling yield and some aspects of management of artificial ponds for the years 1946 through 1951. The number of artificial ponds operated for the rearing of walleye fingerlings in each year of this period was as follows:

1946--1	1949--10
1947--1	1950--15
1948--3	1951--17

Data are presented for all ponds on which information is complete, whether or not they gave a satisfactory yield.

Description of Ponds

These constructed ponds vary considerably in size and shape and they are fairly well scattered throughout the State. The largest in the present series is 53 acres; the smallest, 5 acres. The 62-acre pond listed in table 1 is actually two ponds that were operated as one unit in 1950. Maximum depth of water in these ponds when full ranges from 5½ to 9 feet, and average depth ranges from 3 to 4 feet. Depths increase toward the water-control structure so that the fish can be concentrated in a small area as the pond is drained when harvested. Banks and pond bottoms vary with local soils and may be of sand, muck, clay, or even some peat. The ponds are located so that a water supply is readily available from a stream or lake by gravity flow or pumping.

Since the best results have been obtained by rearing walleyes alone in ponds, every care is taken to exclude other fishes which might enter with the water supply. Screens, filters, or both are used on the intake lines. In spite of these precautions, other fishes sometimes get through and have had, therefore, an unknown effect on the yield of some of the ponds.

Artificial ponds are usually cropped several weeks before the final harvest. At the time of cropping, the water is usually turned on and the fingerlings are seined where they congregate around the water inlet.

Fertilization

Fertilization prior to 1951 was based on earlier experimental fertilization in natural ponds. The fertilizers used were barnyard manure, commercial fertilizer, dry sheep manure, and superphosphate. Rates and types of fertilization for individual ponds are shown in table 1. It should be noted that the figures for barnyard manure are not strictly comparable, since the weight of the loads was usually estimated and the manure varied considerably in water and straw content. Prior to 1951, fertilizer was usually applied in three or four nearly equal portions; the first application was usually made 2 or 3 weeks before the fry were stocked in May and the last about July 1. Intervals between applications of fertilizer ranged from 10 days to 3 weeks.

It became apparent after using the foregoing fertilization scheme that, because of the great difference in the natural fertility of the ponds, some did not need fertilization and some were not fertilized heavily enough. It also appeared that commercial fertilizer tended often to produce an algal crop rather than the desired animal plankton crop. Therefore, in 1951 a detailed chemical and biological study was made on the ponds, and fertilization was based on this. In 1951, all ponds, with the exception of one, were fertilized with natural manures.

TABLE 1.—Walleyed pike fingerling production in drainable constructed ponds

(Ponds ranked according to total yield--pounds per acre)

Name	Size in acres	Year in operation[1]	Fertilizer		Stocking fry per acre	Harvest[3]		Ave. size number per pound[3]	Percentage survival fry--fingerlings
			Kind[2]	Pounds per acre		Number per acre	Pounds per acre		
Melrose	15.00	[4]1	DS	400	40,000	16,415	121.0	135	41.0
Hutchinson	7.00	[4]1	C & B	1,071	57,140	17,290	115.0	150	30.3
Garrison	10.00	6	C	260	70,000	25,740	97.0	265	36.8
Hinckley No. 2	7.50	1	C & B	1,850	53,330	31,485	84.0	376	59.0
Agate	18.00	1	C	333	75,000	29,370	77.0	381	39.0
Mission	45.00	1	C	231	65,880	13,725	75.0	184	20.9
Warren Lake Pond	7.00	[4]1	C	71	57,140	14,805	67.0	220	17.3
Garrison	10.00	7	C	330	60,000	38,120	61.0	629	63.5
Agate	18.00	2	C	333	48,880	22,650	59.0	383	46.3
Bemidji	29.00	1	C	138	41,380	14,745	57.0	260	35.6
Hinckley No. 3	7.35	[4]1	None	-	40,815	10,160	56.0	182	24.9
Hinckley No. 2	7.50	2	None	-	40,000	11,955	55.0	216	29.9
Otter Tail	53.40	1	None	-	37,450	5,470	52.0	104	14.6
Frank D. Blair Pond	26.50	1	C	566	113,200	22,285	50.0	442	19.7
Hinckley No. 2	7.50	3	B	8,800	21,330	14,100	49.0	290	66.1
Shetek Nos. 1 & 2	19.00	1	C	73	36,840	2,705	49.0	55	7.3
Hutchinson	7.00	2	C & B	871	57,140	10,040	48.0	209	17.6
Hutchinson	7.00	3	B & DS	1,257	57,140	1,175	47.0	25	2.1
Cove Bay	41.00	3	None	-	36,100	12,410	46.0	268	34.4
Bemidji	29.00	2	C	69	41,380	8,340	44.0	190	20.1
Shetek No. 1	12.00	2	DS	50	36,660	6,020	44.0	137	16.4
Agate	18.00	4	DS	595	72,220	5,565	43.0	129	7.7
Hinckley No. 3	7.35	2	B	8,980	21,770	11,810	42.0	280	54.2
Big Stone	26.00	2	B	846	40,000	3,690	37.0	100	9.2
Cove Bay	41.00	1	C	293	48,780	8,805	34.0	262	18.0
Mission	45.00	2	C	222	40,000	9,010	32.0	280	22.5
Big Stone	26.00	1	C	577	50,000	3,250	29.0	110	6.5
Frank D. Blair Pond	26.50	3	None	-	52,830	12,570	29.0	432	23.8
Island Lake	37.00	1	DS	724	43,245	13,640	29.0	474	31.5
Straight Lake No. 2	10.00	[4]1	C	176	60,000	7,155	29.0	245	1.3
Sedan No. 1	36.00	2	None	-	33,330	615	27.0	22	1.0
Big Stone	26.00	3	B & DS	1,346	40,000	3,370	20.0	165	8.4
Garrison	10.00	8	B	400	84,000	4,065	18.0	230	4.8
I. W. L. No. 4	5.00	[4]1	C	200	40,000	2,490	18.0	140	6.2
Agate	18.00	2	C	333	36,665	1,965	16.0	124	5.4
Garrison	10.00	11	DS	530	50,000	6,180	14.0	454	12.4
Frank D. Blair Pond	26.50	2	B	981	39,245	1,890	13.0	147	4.8
Garrison	10.00	9	C	200	82,000	2,585	13.0	194	3.1
Garrison	10.00	10	None	-	30,000	1,110	11.0	100	3.7
Bemidji	29.00	3	C & DS	186	41,380	1,515	8.0	180	3.7
Sedan Nos. 1 & 2	62.00	1	C & B	910	39,355	520	7.0	79	1.3
Cove Bay	41.00	2	C	293	32,925	305	6.0	50	.9
I. W. L. No. 4	5.00	3	None	-	40,000	925	6.0	154	2.3
Mission	45.00	4	DS	111	40,000	1,225	3.0	425	3.1
Straight Lake No. 2	10.00	2	DS	190	40,000	190	1.4	135	1.0
Mission	45.00	3	C	267	30,000	130	.3	400	.4
I. W. L. No. 4	5.00	2	SP & DS	512	48,000	0	.0	-	.0

[1] 1 = 1st year; 2 = 2d year, etc.

[2] DS = commercial dry sheep manure; C = commercial fertilizer (8-8-6 or similar); B = barnyard manure (various types); SP = superphosphate.

[3] Includes cropping--total yield. [4] Indicates pond previously used for rearing other species.

Stocking and Harvesting

The ponds were stocked with walleyed pike fry which had been hatched by usual methods. Rate of stocking was usually about 40,000 fry per acre of pond, although (as will be noted in table 1) some ponds were stocked at a higher and some at a lower rate. Usually, stocking was done during the last 2 weeks in May (table 2). It should be noted that the count of fry stocked was only approximate and was based on the count of eggs when eyed, with allowance for losses.

Ponds were usually cropped in midsummer, and part of the small fish removed. This was done, as previously explained, without

TABLE 2.--Cropping and growth of walleyed pike in drainable constructed ponds

(Ponds ranked according to total yield--pounds per acre, as in table 1)

Name	Date stocked	First cropping				Final harvest[1]				Number of times pond was cropped
		Date	Days of growth	Number per acre harvested	Size--number per pound	Date	Days of growth	Number per acre harvested	Size--number per pound	
Melrose	5/21/51	7/17	58	1,756	310	8/28-9/17	130-150	8,976	100	6
Hutchinson	5/13/49	8/5	85	428	150	9/6-9/8	117-119	4,714	150	0
Garrison	5/7/46	7/16	71	7,920	400	9/5	122	217	150	8
Hinckley No. 2	5/14/49	7/14	62	1,333	500	8/14	93	8,540	314	4
Agate	5/18/48	7/8	52	2,166	600	9/20-9/23	126-129	5,100	200	8
Mission	5/18/48	7/1	45	806	300	9/3	109	1,024	160	13
Warren Lake Pond	5/24/50	8/1	70	2,400	240	9/2-9/19	102-121	6,714	240	3
Garrison	5/25/47	7/10	47	20,020	1,300	8/11-8/12	79-80	1,700	200	4
Agate	5/10/49	7/7	59	6,233	460	8/26-8/31	109-114	7,600	300	3
Bemidji	5/11/49	8/16	98	3,720	260	8/23-8/25	121-123	6,271	260	2
Hinckley No. 3	6/5/50	8/22	79	612	225	9/19-9/23	107-111	5,877	160	2
Hinckley No. 2	6/5/50	8/22	79	1,888	240	9/19-9/23	107-111	8,736	210	2
Otter Tail	5/19/51	8/7	81	433	120	8/27-9/1	101-106	457	75	8
Frank D. Blair Pond	5/6/49	6/27	53	1,675	800	9/15-9/27	133-145	1,377	193	15
Hinckley No. 2	5/22/51	7/27	67	904	295	8/16-8/18	87-89	9,589	290	2
Shetek Nos. 1 & 2	6/8/50	Not cropped		0	-	9/13-9/14	98-99	2,706	55	0
Hutchinson	5/22/50	7/11	51	5,142	400	9/15-9/25	117-127	4,900	140	1
Hutchinson	5/16/51	Not cropped		0	-	8/15-8/28	92-99	1,177	25	0
Cove Bay	5/24/51	7/18	56	1,043	400	9/13-9/17	113-117	2,707	150	11
Bemidji	5/28/50	Not cropped		0	-	8/21-8/23	86-88	8,340	190	0
Shetek No. 1	5/17/51	8/1	77	862	150	8/22	98	320	120	5
Agate	5/24/51	7/7	45	694	500	9/5-9/7	105-107	2,000	100	7
Hinckley No. 3	5/22/51	7/27	67	1,409	280	8/19	90	8,876	280	2
Big Stone	5/27/50	Not cropped		0	-	9/18-9/29	115-126	3,692	100	0
Cove Bay	5/10/49	7/14	66	6,301	380	9/15	129	938	60	4
Mission	5/9/49	7/6	59	2,784	330	9/1-9/9	116-114	554	110	3
Big Stone	5/12/49	7/7	57	960	240	9/28-10/6	140-148	875	85	3
Frank D. Blair Pond	5/20/51	7/6	48	1,652	600	8/1-8/10	74-83	1,183	150	10
Island Lake	5/21/51	7/10	51	2,276	1,040	8/27-9/24	99-127	1,099	420	3
Straight Lake No. 2	5/30/50	Not cropped		0	-	8/25-8/31	88-94	7,154	245	0
Sedan No. 1	5/22/51	7/9	49	33	300	9/4-9/21	106-123	313	12	6
Big Stone	5/22/51	8/9	80	467	190	9/24-9/28	126-130	470	120	7
Garrison	5/18/48	7/10	54	2,400	240	8/11	86	800	200	2
I. W. L. No. 4	5/13/49	Not cropped		0	-	8/15-8/16	95-96	2,492	140	0
Agate	6/5/50	8/7	64	850	150	8/21-8/22	78-79	1,118	110	1
Garrison	5/24/51	7/13	51	3,700	500	7/26-7/27	64-65	2,480	400	1
Frank D. Blair Pond	5/26/50	7/24	60	976	244	9/9-9/11	107-109	116	70	5
Garrison	5/10/49	7/15	67	2,235	207	7/29	81	350	140	1
Garrison	6/5/50	8/9	66	390	130	9/5	93	720	90	1
Bemidji	5/22/51	Not cropped		0	-	8/21-8/22	92-93	1,514	180	0
Sedan Nos. 1 & 2	5/27/50	7/25	60	67	140	8/17	83	126	50	7
Cove Bay	6/5/50	Not cropped		0	-	9/13-9/14	101-102	304	50	0
I. W. L. No. 4	5/28/51	Not cropped		0	-	9/4	100	924	154	0
Mission	6/4/50	Not cropped		0	-	8/2	60	133	400	0
Straight Lake No. 2	5/18/51	Not cropped		0	-	9/15	121	189	135	0
Mission	5/24/51	7/9	47	623	425	-	-	-	-	3
I. W. L. No. 4	6/6/50	Failure	-	-	-	-	-	-	-	-

[1] Figure for final harvest only; for total harvest, see table 1.

draining the pond. The fingerlings taken by such cropping ranged in size from 120 to 1,300 to the pound, with an average of 372 to the pound, and ranged in age from 45 to 98 days, with an average of 62 days. In the fall (usually between September 1 and September 25), the ponds were harvested by draining them to a small pool and then removing the fingerlings with seines. At harvesting, the fish ranged from 60 to 150 days in age and ranged from 12 to 420 to the pound in size.

Total yield was obtained by adding the cropping results to the final harvest. It is obvious that such a total exceeds the weight or number of fish in the pond at any one time. Experience has shown that unless the fingerlings are cropped, they often tend to grow slowly and become thin late in the summer.

Several attempts have been made to feed the walleye fingerlings with suckers and minnows, but thus far little success has been had, as judged by size of yield.

Total Yield

Under the management plan already outlined, ponds have varied considerably in yield, the weights ranging from 0.3 to 121 pounds per acre with an average of 39.9 pounds per acre, and the numbers from 130 to 38,120 fingerlings per acre with an average of 9,425 per acre.

Survival from fry to fingerling size (the cropped fish included) ranged from 0.4 to 66.1 percent with an average of 19.2 percent.

In both tables the ponds are arranged in order of yield in pounds per acre. So many factors influence the yield of ponds (many of which factors are poorly understood), that it is not possible to make a detailed statistical analysis of the effect of these factors. Some general observations, however, can be made:

1. There appears to be no consistent relationship between size of pond and yield.
2. Stocking rate within the range given appears not to affect yield.
3. Ponds tend to yield best in the first year after filling and then decline in yield in the second and third years. This suggests that decay of flooded bottom soil may be a factor in producing a suitable food crop.
4. Inconsistency of results from fertilizers and manures suggests that more consideration should be given to the natural fertility of the ponds. It should also be noted that in draining these ponds there is a considerable loss of natural fertility with the water.

INFORMATION REGARDING TOXIC COMPOUNDS OR EFFLUENTS

Suggestions and comments are solicited for a special project that has recently been initiated by the Fish and Wildlife Service at the Leetown Experimental Fisheries Station.

This project is an investigation to improve methods for taking fish. One of the primary objectives is to locate a chemical agent which is superior to rotenone. Present plans are to screen several thousand chemicals for toxicity to different species of fish. It is felt that fishery investigators throughout the country may have had occasion to note toxic compounds or effluents which would be of value directly or as indicators to chemically related toxic compounds.

Correspondence should be directed to Dr. S. F. Snieszko, Microbiological Laboratory, U. S. Fish and Wildlife Service, Kearneysville, West Virginia.

"ECHO SOUNDING MASSACHUSETTS' LAKES, PONDS, AND RESERVOIRS"

Richard H. Stroud and Frank Grice
The Progressive Fish-Culturist, 14 (2): 56-60

CORRECTION:

The description of the apparatus used in this work (second paragraph under the heading The Instrument and Its Mounting, page 57) should have begun:

"The latter [electronic components], housed in a water-tight indicator case and incorporating a three-stage tuned amplifier, operate at 400 soundings per minute transmitted into and received from the water below the surface through a single transmitting and three receiving units known collectively as the transducer."

RATE OF SURVIVAL OF LARGEMOUTH BLACK BASS FRY STOCKED IN EXPERIMENTAL FARM PONDS

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THE SUCCESS OF ANY FARM POND for fishing depends not only upon the number of fish of different species stocked but also upon the survival rate of these stocked species, since both determine the future ratio of predator fish to forage fish in the pond. Therefore, in designing any stocking procedure for farm ponds, the survival rate of the stocked fish, especially the predator species, must be taken into consideration.

This paper embraces the results of 10 experimental farm ponds located at the A. E. Wood State Fish Hatchery, San Marcos, Texas. The ponds were stocked primarily to compare various stocking ratios and species combinations. These aspects have been covered by Brown (1951). The species stocked included the largemouth black bass (Micropterus salmoides), bluegill (Lepomis macrochirus), redear sunfish (Lepomis microlophus), and yellowbelly sunfish (Lepomis auritus). The ponds ranged in size from 0.53 to 2.45 acres. The ponds were stocked in April 1949 with bass fry up to 1 inch in total length. The sunfish were stocked the following October and November and were 1 to 2 inches in total length. All fish stocked were reared at the hatchery and taken from groups destined for farm ponds. Hence, the fish were stocked during the regular delivery periods for the various species. The ponds were drained during June, July, and August 1950; the fish were immediately sorted, counted, measured, and weighed. All the ponds were operated 14 to 16 months, and none were fished during this period. All ponds received 4-12-4 fertilizer at the rate of 400 pounds per acre. Very few ideal blooms of unicellular algae were obtained during this period.

Davis (1928) reported a loss of less than 50 percent with a total production of approximately 8,000 3-inch bass per acre at the Fairport, Iowa, Station of the U. S. Bureau of Fisheries as a result of stocking bass fry. Davis (1929) reported an average loss of less than 60 percent from stocking bass fry in rearing ponds at the Fairport Station. Davis (1930) recorded an average survival rate of 35 to 40 percent, with one instance of 56 percent, from stocking bass fry in rearing ponds. This work was also done at Fairport. Hayford (1932) reported losses of 14.2 and 32.4 percent in raising bass fry to fingerlings in two ponds at the Hackettstown, New Jersey, State Fish Hatchery. Hogan (1933), at the State Fish Hatchery at Lonoke, Arkansas, reported 60 percent survival in one pond that was fertilized and stocked with golden shiner minnows. In three other ponds that were fertilized, he received survival rates of 50, 54, and 49 percent. All four ponds were used to produce 3-inch fingerlings. Meehean (1939) obtained a survival of 84.77 percent for bass fry in rearing ponds at the end of 39 days, a survival of 72.50 percent at the end of 71 days, and a survival of 67.70 percent at the end of 113 days. These results were obtained at the U. S. Fisheries Station at Welaka, Florida. Mr. R. P. Winn, superintendent of the A. E. Wood State Fish Hatchery at San Marcos, Texas, supplied the author with the following information obtained from stocking bass fry in hatchery rearing ponds in 1949. Twenty-three ponds stocked with fry at the rate of 10,000 per acre yielded survival rates of 5.0 to 82.0 percent with a mean of 46.7 percent.

The above data give some insight as to the survival rate of largemouth black bass fry, but still they represent only the raising of bass fry to fingerlings when stocked in hatchery rearing ponds at the rate of 10,000 to 50,000 per acre. The above data would not be valid for farm ponds stocked for longer periods of time at the rate of 100 to 500 bass per acre. Far less information is available under these circumstances. Smith and Swingle (1943) reported the following results: A pond 1.8 acres in size was stocked with 400 bluegill fingerlings and 100 bass fry per acre.

The survival rate of the bass fry was 90 percent. The pond was operated less than a year. With bass fry and forage fish combinations, Swingle (1949) received the following results: Bass fry were stocked at the rate of 200 per acre with bluegills, golden shiners, shad, and goldfish. The ponds (except the bass-golden shiner combination pond, which was operated about 1 year) were drained about 6 months after the bass were stocked. Survival rates for the bass fry ranged from 32 to 86 percent with a mean of 70 percent. In four other ponds, combinations of bass fry stocked at the rate of 100 per acre with bluegill and golden shiners were tested. The ponds were drained about 18 months after the bass were stocked. Survival rates for the bass fry ranged from 40 to 92 percent with a mean of 68.5 percent.

Results from a 10-pond experiment conducted by the author are recorded in the table. Bass fry were stocked without forage species and in combination with forage species including bluegill, redear sunfish, and yellowbelly sunfish. All ponds were operated approximately 15 months. Bass fry survival rates ranged from 64.4 to 85.3 percent with a mean of 71.3 percent. The higher survival rates were obtained with stocking ratios of 400 to 200 bass fry only per acre, but the fish recovered were smaller than those obtained from ponds stocked at lower ratios with forage species. As can be seen from the table, the survival rates were grouped within rather a small range (64.4 to 85.3 percent) and did not seem influenced greatly by any one factor. As all ponds were fertilized alike and received equal treatment in other respects, the results should represent approximately what can be expected from stocking bass fry in Texas farm ponds. The mean survival rate, 71.3 percent, also agrees with the series of ponds reported by Swingle (1949), as his mean survivals amounted to 70 and 68.5 percent respectively.

Survival rates would be expected to vary, owing to geographic location and climatic conditions. Nevertheless, there seems not to be too much variation when series of ponds are averaged and compared with averages from other locations. Brown (1952) reported a mean survival rate for largemouth black bass fingerlings in Texas farm ponds as 65.0 percent. Thus the survival rate of bass fry (71.3 percent) exceeded that of the bass fingerlings.

Smith and Swingle (1943) made the following observations:

> The greater percentage of survival for bass fry planted in new ponds, as compared to that for fingerlings, is explained by the relative abundance of food available for each immediately following planting. The fry, which are planted in the spring, thrive on microcrustacea and aquatic insects for some time and young bluegills are available by the time they are large enough to eat them. The fingerlings usually are planted in the fall or winter. Although they need fish for an adequate diet, they must subsist on aquatic insects, tadpoles, and possibly some Gambusia until the bluegills spawn the following spring.

The advantages of stocking bass fry rather than bass fingerlings in new farm ponds are rather obvious. More bass fry are available; loss due to raising fish to fingerling size in crowded hatchery ponds is overcome, as well as the cost of such operation.

Bass fry stocking is also practical for large lakes and reservoirs. Marion Toole, chief aquatic biologist of the Texas Game and Fish Commission, gave this report (1947):

> ...We knew from experience that largemouth black bass fingerling plantings made in large reservoirs did little toward affording better fishing and as was previously pointed out, they were essential for the farm-pond program. Apparently, the failure of bass fingerling stocking in reservoirs was due to the fact that sufficient numbers could not be produced to make an

Survival rates from stocking largemouth black bass fry

Stocking ratio in fish per acre	Size of pond in acres	Months operated	Percentage survival of bass fry	Mean percentage survival of bass fry
1/ 200 bass	0.56	14	85.3	
1/ 400 bass	0.62	14	75.5	
100 bass : 1,000 bluegill	0.56	14	72.0	
1/ 200 bass : 25 redear sunfish	0.53	15	65.9	71.3
1/ 150 bass : 100 redear sunfish	1.50	15	64.5	
100 bass : 1,000 yellowbelly sunfish	1.32	15	64.4	

1/ Average of two ponds.

observable change in the population of the lake. We knew that we could produce largemouth bass fry in huge numbers. This was done and several new reservoirs were stocked with bass fry at the rate of 150 per surface acre of water. Boats were designed and built in order that bass fry could be spread thin along the whole shore line. One large reservoir, Lake Travis (11,000 acres), was completed and filled just prior to the completion of Possum Kingdom (26,000 acres) and Lake Texoma (95,000 acres). Lake Travis was not given an initial stocking of bass fry, but fry were planted in Possum Kingdom and Lake Texoma. Bass fry placed in Lake Texoma in April attained an average growth of 10 inches by October 20, when fishing was opened on the Texas side. A like growth rate was noted in Possum Kingdom Lake. It should be pointed out that the planted fry were not marked, but their growth rate was checked by periodic seine sampling. The fishing in Possum Kingdom and Lake Texoma has been extremely good from their opening days, but the fishing in Lake Travis was very disappointing for a new lake.

Later talks with Mr. Toole revealed that bass fry were restocked with great success in Possum Kingdom Lake as bass fishing began to decline. Schools of fry were seen periodically around the shore line where they were stocked. Bass fishing increased and was again extremely good, especially the second year after stocking.

Thus the possibility is raised that agencies in charge of fish-cultural activities may someday decide that raising bass to fingerling size is of little benefit and does not compensate for the expended time, money, and effort. Smith and Swingle (1943) stated:

> Fish-culturists can, in effect, increase the productivity of bass hatcheries by using advanced fry instead of fingerlings for stocking new ponds. Since an average mortality of 50 to 60 per cent is experienced in the hatchery in rearing fry to the fingerling stage, the use of fry instead of fingerlings would approximately double the number of fish available for stocking.

This seems to be the trend in Texas fisheries and is gaining momentum each year. A survival rate of 71.3 percent for fry stocked in farm ponds, as compared with 50 percent or less survival for fry in hatchery rearing ponds and 65 percent survival in farm ponds from stocking these fingerlings, is in itself enough to compensate for stocking State waters with fry. The added cost and effort only aid in tilting the pointer more in the same direction.

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REPRINT

FARM PONDS--FOR CATTLE OR FOR FISH?

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For what purpose was your pond built? For stock water probably, but you undoubtedly would like to use it for fishing as well. You are not alone. There are at least 100,000 ponds in Oklahoma and several thousand more being built each year.

Most of these were and are being constructed to provide water for the farmer's stock, and practically all types of ponds will serve that primary purpose. However, very few ponds that are used for stock tanks can be expected to supply, in addition, the proper kind of fishing, because conditions created in and around a pond by cattle or horses are generally unsuitable for good fish production.

Despite this fact, the files of the state game and fish department's division of fisheries are filled with requests for fish to put in such ponds.

Let's look at what Oklahoma fish need to survive and grow in ponds of this state, then at some ways in which cattle interfere with or destroy these conditions, and finally at some of the typical stock ponds for which fish applications are received. This should help you to decide whether or not your pond can provide good fishing, or to understand why the state inspector may not recommend stocking it with the type of fish you want, or possibly flatly turns down your application.

Bass, channel catfish, crappie, bluegill, and red-ear sunfish are the principal fishes stocked in Oklahoma ponds by the state hatcheries. Generally speaking, bass are planted in the larger and clearer ponds, and channel catfish in those that tend to stay muddy. Crappie are gradually being eliminated from the small pond stocking program because their tendency to reproduce in large numbers results in rapid over-stocking of the pond, stunted fish, and generally poor fishing. However, crappie are still recommended for ponds of five acres or more. Bluegill and red-ears are pan-fishes which serve as food for the larger bass and catfish.

In order to produce good fishing for these species, a pond must have a large water surface, some deep and some shallow areas, clear water (except for channel cat), green vegetation, and plenty of food. The last is probably the most important essential for the growth of fishes, but it is dependent among other things on the physical conditions of the pond.

Any pond will support only so many pounds of fish, depending on its size and the food available. There can be a large population of large and medium size fish, which makes for good fishing, or a large number of very small fish and a few large ones, which means poor fishing. The amount of available space is important. The larger the pond, the more pounds of catchable fish of all species will it support. The average Oklahoma stock pond of a half-acre or less will hardly provide enough food and space for more than a handful of eating-size fish. Two acres is a good minimum size fish pond.

As well as lots of water, fishes need deep areas where they can retreat from the surface during summer days and cold winter weather. Furthermore, a pond should have enough depth that there will be no danger of its drying up during periods of drouth.

The amount of shallow water is equally important, since spawning and feeding activities of a fish mainly occur in this region of a pond. Also, the amount of basic fertility of a pond, i.e., the chemical elements which are the beginnings of all plant and animal life, are directly proportional with the amount

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of shallow water. Ponds having about two-thirds of their area shallow (from one to five feet), and the remaining one-third of the area five to ten feet in depth, are the most productive for fishes.

All of our pond fishes except the channel cat need clear water if they are to grow well. They feed almost entirely by sight, and muddy water interferes with this. That is why many bass and sunfish from muddy ponds are stunted or poor, and why they are recommended to be placed only in clear water. Channel catfish, on the other hand, feed largely by a strong sense of smell and they are able to survive and grow in muddy as well as clear ponds. Clear water is necessary, too, for the production of green vegetation, of a good food supply, and the growth of the fishes themselves.

To understand how fishes grow, one must first understand the food chain which is present in a pond. At the very bottom of the chain is the basic fertility. The interaction of these basic elements with sunshine, air and water, produces millions of microscopic plants, fed upon by millions of microscopic animals. These in turn are the food of insects and the newly hatched young fish, which themselves serve as food for larger insects and small fish such as the bluegill and other sunfishes. At the top of the chain are the large bass, crappie and catfish, which feed on the smaller fish. The chain goes a step further when we catch the larger fish for our own tables.

When ponds are muddy, this food chain is broken because the sun's rays cannot penetrate through to start the production of the microscopic plants. Young fish have little or no food, and the reaction goes right on to the top of the food chain, resulting in poor growth of the larger fishes. If we depended entirely on the fishes from muddy ponds for our food, we, too, would be in poor shape. Muddy water and good fishing do not go hand in hand.

These are some of the physical conditions needed by pond fishes. Now how do livestock affect these conditions?

Most noticeable is the fact that small stock tanks are usually muddy. Not all of the muddy waters can be blamed on the livestock, since the clearness of any pond is determined by the soil on which it is built, and the conditions of the watershed surrounding it. But if cattle use a pond for drinking water, they generally keep it roiled by their wading. A large water area may offset the effects of wading stock, but the average size stock tank is too small to ever clear permanently.

The latest fish stocking policy of the Oklahoma Game and Fish Department states that ponds subject to extreme turbidity due to erosion, wading of livestock, or other causes, will not be stocked until properly fenced and the water cleared.

Other harmful effects of livestock around a farm pond where fishing is desired include the breaking down of banks and the dam from the continued beating of hooves, the destruction of vegetation on the dam and around the shorelines, and the silting in of shallow areas, with the destruction of nests and feeding areas.

Typical stock tanks built in Oklahoma fall into four general classes: (1) the circular deep hole; (2) the long and shallow prairie pond; (3) the gully pond; and (4) the mud-hole. Number one is most common and, as implied, is simply a deep hole dug out of the ground and the earth used to throw up a dike three-quarters or completely around the pond. This type, though deep, is usually small, one-half acre or less. There is little danger of the pond going dry, but neither is there any shallow water for production of food or for fish spawning purposes. Moreover, the steep banks are subject to heavy wash and erosion.

The second type of pond is made from a low place on generally flat land. Usually it is so shallow that it becomes easily roiled or, if clear, becomes too crowded with aquatic plants for good fish production.

For the gully pond a dam is thrown across a ravine, canyon or gully. Although this type is usually larger and deeper than the others, it also is usually filled with silt from the watershed which washes down the gully and is potentially poor for fish because the fertility is flushed out with each rain.

The tank classed as a mud-hole means any watering area from one-tenth to one-quarter of an acre, and is for too many obvious reasons useless for any fish production except bullheads or green sunfish, and these will stay very small. Nevertheless, the state receives many applications for fish for this type of pond. There are exceptions, of course, in which some of the ponds named have produced fair fishing, but generally the average stock tank is too small, too deep or too shallow, and too muddy to produce the kind of fishing the owner wants and usually expects.

This is by no means intended to discourage pond owners from stocking their water with fish, if the ponds meet the requirements for good fishing. It is the program of the state

game and fish department to promote better fishing for the greatest number of people, and its inspectors will be the first to suggest stocking a good pond. They will also be the first to tell you that your pond could not be expected to produce any fishing and that it will be a waste of time, money and effort to stock it, if that be true.

Before you submit your application for fish, it should be understood that many ponds are simply of no use as fishing waters, and that others are designed to serve more valuable purposes which, in themselves, remove the possibility of good fishing. Consider the purpose for which your pond was built. If it was for stock water and it falls under one of the four categories described, then don't expect it to provide good fishing in addition.

If your stock pond fills the minimum requirements of size and depth and you desire to use it for fishing, too, then fence it and install a drain pipe with water tank below the dam. The harmful effects of cattle toward fish will then be eliminated, yet stock water will still be available. If this can't be done, then the only other solution is to build another pond entirely for fishing. Building and maintaining a private fishing pond is too expensive for most farmers, yet this is the best solution as far as good fishing in farm ponds is concerned.

Keep the main purpose of your farm pond in mind and use the pond for that alone to obtain maximum benefits from it. It's a poor fish that has to play second fiddle to a herd of wading cattle. So for best fishing results, let's keep them separate--stock ponds for stock, fish ponds for fish. To each his own!

CLEARING HOUSE

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INDEX

Absorption of radioactive
calcium by brook trout. ------- 154-158
Aid in the application of
rotenone in pond
reclamation. ---------- 31-32
Anemia, brown trout ---------- 152-153
Anesthesia
chloretone ---------- 78
urethane ---------- 9
Antibiotics
experiments with, and
vitamin B_{12} ---------- 148-153
in ulcer disease ---------- 44-47
Argulus outbreaks in
Minnesota lakes. ---------- 70
Ascorbic acid and rhamno-
sides from sea water. --------- 153
Azevedo, R. L. ---------- 122-124

Balzer, G. C., Jr. ---------- 67-70
Bass
largemouth black
blood study ---------- 169-172
Florida fishery ---------- 99
netting of ---------- 18
propagation ---------- 61-64
stocking ---------- 27-28
survival ---------- 79-80, 177-179
rock ---------- 18
striped ---------- 125-126
Baten, W. D. ---------- 50-55
Bennett, L. H. ---------- 30
Biotin,
pantothenic acid, and
brown trout. ---------- 67-70
torula yeast study ---------- 8
Blindness, brown trout ---------- 152-153
Blood, fish ---------- 169-172
Blosz, John ---------- 61-66
Bluegill
blood study ---------- 169-172
Florida fishery ---------- 99-100
propagation ---------- 64-66
stocking ---------- 27-28,
79-80, 177-179
Blue-slime disease ---------- 67-70
Bond, C. E. ---------- 9
Brice, R. F. ---------- 104-109
Brockway, D. R. ---------- 19-22, 67-70
Brown, W. H. ---------- 79-80, 177-179
Brunner, G. ---------- 132

Buffalo
blood study ---------- 169-172
propagation ---------- 129-130
Bullhead
blood study ---------- 169-172
parasitized ---------- 70
stocking ---------- 27-28
Burrows, R. E. ---------- 78,
113-116, 122-124

Calcium, radioactive,
absorbed by brook
trout ---------- 154-158
Carlander, K. D. --------- (reviews) 38-40
Carp
blood study ---------- 169-172
dropsy ---------- 132
removal from ponds ---------- 28
spines sectioned ---------- 36
Catch, effect of trout
stocking on ---------- 117-121
Catfish
Florida fishery ---------- 98-99, 102
removal from ponds ---------- 28
Char
fertility ---------- 39-40
spawning activities ---------- 38-39
Chloretone used to
anesthetize salmon
fingerlings. ---------- 78
Churchill, W. S. ---------- 3-9
Clamp, brush ---------- 73
Clearing House ---------- 40,
83-84, 132, 182
Clemens, H. P. ---------- 31-32
Columnaris, observations
on, salmon and trout ---------- 104-109
Commercial fisheries ---------- 98-103
Comparative morphologic
and physiologic study
of fish blood. ---------- 169-172
Comparison of the growth
of fingerling chinook
salmon reared in
ponds, troughs, and
circular tanks. ---------- 76-78
of lake trout finger-
lings from eggs
taken in Seneca,
Saranac, and
Raquette Lakes. ---------- 15-18

Comparison of the growth rates of chinook salmon fingerlings reared in circular tanks and Foster-Lucas ponds. ---------- 122-124
Cope, O. B. ---------- 125-126
Cornell, J. H. ---------- 117-121
Counter, egg ---------- 81-82
Crappie
black, stocking ---------- 79-80
Florida fishery ---------- 98-99, 102
removal from ponds ---------- 27
white, blood study ---------- 169-172
Culver, Ray ---------- 9
Cutter, spine ---------- 36

Dequine, J. F. ---------- 98-103
Diet studies
all-meal diet, brown trout ---------- 110-112
antibiotics, vitamin B_{12}, brown trout ---------- 148-153
biotin, pantothenic acid, brown trout ---------- 67-70
fats, supplemental, brook trout ---------- 19-22
gill disease and nutrition, salmon ---------- 10-14
torula yeast, brook trout ---------- 3-9
Disease studies
blue-slime, brown trout ------- 67-70
columnaris, salmon and trout ---------- 104-109
dropsy, carp ---------- 132
furunculosis, brook trout ---------- 43-47
gill, salmon ---------- 10-14
red mouth, rainbow trout ---------- 127-128
red sore ---------- 43
ulcer brook trout ---------- 43-49
Dobie, John ---------- 23-26
Dropsy, carp ---------- 132

Echo sounding Massachusetts' lakes, ponds, and reservoirs. ---------- 56-60, 176
Effect of trout stocking on the rate of catch. --------- 117-121
Effects of injected pituitary material on the spawning of blueback salmon. ---------- 113-116
supplemental fats in the diet of brook trout. ---------- 19-22
Egg
inventory: enumeration with the egg counter. ---------- 81-82
washer. ---------- 116
Eggs
enumeration ---------- 81-82
Eggs (continued)
fertilization ---------- 165-168
fungus control, pike --------- 30
growth, three lake trout strains ---------- 15-18
Elektromikroskopische untersuchungen über den erreger der infektiösen bauchwassersucht der karpfen--bakterium oder virus? (reviewed) ----- 132
English, T. S. ---------- 36
Enumeration, egg ---------- 81-82
Equipment
clamp, brush ---------- 73
counter, egg ---------- 81-82
cutter, spine ---------- 36
feed dispenser ---------- 124
inks ---------- 125-126
net
dip ---------- 172
gill ---------- 18
pliers ---------- 32
press, hydraulic ---------- 97
screens, roll-away ---------- 121
sounder, echo ---------- 57-58, 176
spray, power ---------- 31-32
trolley ---------- 37
washer, egg ---------- 116
Experiments with antibiotics and vitamin B_{12} in the diets of brown trout fingerlings. ---------- 148-153

Fabricius, Eric ---------- 38
Farm ponds--for cattle or for fish? (reprint) -------- 180-182
Fats, supplemental, in brook trout diet ---------- 19-22
Federal aid, fish restoration projects ---------- 135-147
Feed dispenser ---------- 124
Fertility of char in Foxalven water system, Sweden. (reviewed) ---------- 39-40
Fertilization experiments at Bare Lake, Kodiak Island. ---------- 158
Fertilizer
pond renovation ---------- 29
propagation
bass ---------- 62-64
bluegill ---------- 64-66
pike ---------- 173
Fin regeneration ---------- 72
First year of Federal aid in fish restoration. ---------- 135-147
Florida, public sentiment in fishery management ---------- 98-103
Forage fish ---------- 23-26
Frank, P. T. ---------- 129-130
From report on study of nylon and linen gill nets. ---------- 18

Fungus, control ---------- 30
Furunculosis
test, rapid presumptive ---------- 74-75
treatment, trout ---------- 43-47

Gametes, viability ---------- 165-168
Garlick, L. R. ---------- 116
Gastineau, A. C. ---------- 76-78
Gill disease, interim report ---------- 10-14
Goldfish, blood study ---------- 169-172
Grice, Frank ---------- 56-60, 176
Griffin, P. J. ---------- 74-75
Growth
salmon, chinook -------- 76-78, 122-124
shad ---------- 33-36
trout
brook ---------- 3-9, 19-22
brown ---------- 67-70, 110-112, 148-153
lake ---------- 15-18, 71-73

Hall, G. E. ---------- 180-182
Halver, J. E. ---------- 121
Haskell, D. C. ---------- 15-18, 71-73, 81-82, 87-97
Hasler, A. D. ---------- 165-168
Heterogeneous stimulus summation in the release of spawning activities in fish. (reviewed) ---------- 38-39
Hiner, L. E. ---------- 97
Holloway, A. D. ---------- 27-29

Improved dip net. ---------- 172
Inks for marking plastic fish tags. ---------- 125-126
Interim report on gill disease. ---------- 10-14

Jaxtheimer, R. ---------- 132
Jensen, C. C. ---------- 37
Johnson, H. E. ---------- 10-14, 76-78, 104-109

Kaplan, H. M. ---------- 169-172
Kaydas, G. M. ---------- 10-14
King, Willis ---------- 135-147

Labor to produce fifty tons of trout: a time study. ---------- 87-97
Lake trout production and estimate of losses resulting from sea lamprey depredations. ---------- 49
Lamprey, sea, depredations ------- 49
Lawrence, W. M. ---------- 71-73
Lewis, W. M. ---------- 169-172
Louse, fish ---------- 70
Lovelace, G. E. ---------- 67-70, 154-158

Maar, A. ---------- 39-40
Malachite green, fungus control ---------- 30
Mapping, echo sounder ---------- 56-60
Marking cutthroat trout with trypan blue. ---------- 9
Maxwell, J. M. ---------- 19-22
Measurements, body, smelt ---------- 50-55
Method of
calculating fish production in rearing ponds. ---------- 23-26
sectioning carp spines for growth studies. ---------- 36
Miller, Fred ---------- 173-176
Minerals, dissolved, absorption of ---------- 154-158
Minnow production, calculation ---------- 23-26
Modification of hydraulic press for making impressions of fish scales. ---------- 97

Natural selection and egg number in fish. (reviewed) ---------- 39-40
Nelson, P. R. ---------- 158
Net
dip ---------- 172
gill ---------- 18, 131
Newman, H. W. ---------- 113-116, 122-124
Note on experiments designed to test the viability of gametes and the fertilization of eggs by minute quantities of sperm. ------- 165-168
Nursall, J. R. ---------- 165-168

Observations on columnaris in salmon and trout. ---------- 104-109
Operation mackinaw. ---------- 131

Palmer, D. D. ---------- 113-116, 122-124

Pantothenic acid,
biotin, brown trout ---------- 67-70
Pearson, J. C. ---------- 33-36
Perch, netting of ---------- 18
Perkins, C. L. ---------- 127-128
Peterson, K. L. ---------- 18
Phillips, A. M., Jr. -------- 19-22, 67-70
Pike
eggs, fungus control ---------- 30
parasitized ---------- 70
production ---------- 173-176
spawning ---------- 38
Pituitary material,
effects on blueback salmon spawning ---------- 113-116
Plant control ---------- 66
Pliers for tagging
fish with flat fingerling strap tags. ---------- 32
Podoliak, H. A. ---------- 154-158
Ponds
bait-rearing ---------- 23-26
farm
bass survival in ----- 79-80, 177-179
cattle or fish ---------- 180-182
renovation ---------- 27-29, 31-32
hatchery
bass ---------- 61-64
bluegill ---------- 64-66
salmon ---------- 76-78, 122-124
shad ---------- 33-36
Preliminary report on control of fungus in eggs or pike with malachite green. ---------- 30
Press, hydraulic, modified ------- 97
Production
calculation of,
in rearing ponds ---------- 23-26
trout, time study ---------- 87-97
Propagation of
buffalo. ---------- 129-130
largemouth black bass and bluegill sunfish in Federal hatcheries of the Southeast. ---------- 61-66
Pseudomonas hydrophila,
the cause of "red mouth" disease in rainbow trout. ---------- 127-128
Public sentiment: an important factor in fishery management. ---------- 98-103
Pumpkinseed
netting ---------- 18
removal from ponds ---------- 27-30

Quickly changed brush clamp. ---------- 73

Radioactive calcium,
absorption ---------- 154-158
Rapid presumptive test for furunculosis in fish. ---------- 74-75
Rate of survival of
largemouth black bass
fingerlings stocked in experimental farm ponds. ---------- 79-80
fry stocked in experimental farm ponds. ---------- 177-179
Ratledge, H. M. ---------- 117-121
Rearing young shad in ponds. ---------- 33-36
Reclamation, pond ---------- 31-32
Renovation, pond ---------- 27-29
Red mouth disease ---------- 127-128
Relationships of
weight and body measurements of adult smelt. ---------- 50-55
Reprint ---------- 180-182
Restoration projects, Federal aid ---------- 135-147
Reviews ---------- 38-40, 132
Rhamnosides ---------- 153
Robinson, R. S. ---------- 131
Roegner-Aust, S. ---------- 132
Roll-away screens on hatchery troughs. ---------- 121
Rotenone, application ---------- 28, 31-32
Rough fish ---------- 98, 102
Rucker, R. R. ---------- 10-14
Rupp, R. S. ---------- 32

Saeugling, E. C. ---------- 30
Salmon
blueback
gill disease ---------- 10-14
pituitary ---------- 113-116
chinook
columnaris ---------- 104-109
gill disease ---------- 10-14
growth ---------- 76-78, 122-124
egg washer ---------- 116
silver
columnaris ---------- 104-109
gill disease ---------- 10-14
Scale studies of lake trout on the Great Lakes. ---------- 168
Scales, impressions ---------- 97
School of fisheries. ---------- 159-164
Schumacher, R. E. ---------- 70
Screens, roll-away ---------- 121
Shad, rearing ---------- 33-36
Sharkey, R. F. ---------- 73
Sharp, R. W. ---------- 30
Smelt, body measurements, weights ---------- 50-55
Smith, C. G. ---------- 169-172
Snieszko, S. F. ------ 43-49, (review) 132
Some pathological symptoms in brown trout on an all-meal diet. ---------- 110-112
Sounder, echo ---------- 56-60, 176
Spawning
heterogeneous stimulus -------- 38-39
injected pituitary ---------- 113-116
Sprayer, rotenone ---------- 31-32
Stefanich, F. A. ---------- 172

Stocking
farm ponds
corrective ---------- 27-29
experimental -------- 79-80, 177-179
hatchery ponds ---------- 62-65
trout water ---------- 71-73, 117-121
Stroud, R. H. ---------- 56-60, 176
Sucker
spotted ---------- 169-172
white ---------- 23-26
Suggestions for the
renovation of fish
ponds. ---------- 27-29
Sunfish
bluegill
Florida fishery ---------- 99-100
propagation ---------- 64-66
stocking ---------- 79-80, 177-178
green ---------- 28
longear ---------- 28
redear ---------- 27, 99-100, 177-178
yellowbelly ---------- 27, 177-178
Supplement to fertility
of char in Foxalven
water system,
Sweden. (reviewed) -------- 39-40
Survival and growth of
stocked lake trout
yearlings from
Seneca and Raquette
Lake breeders. ---------- 71-73
Svardson, G. ---------- 39-40

Tack, P. I. ---------- 50-55
Tagging pliers ---------- 32
Tags, plastic ---------- 125-126
Tanks, circular ---------- 76-78, 122-124
Temperatures, water,
relation to columnaris -------- 104-109
Time study,
trout production ---------- 87-97
Torula yeast,
trout diets ---------- 3-9
Trolley, trout ---------- 37
Trout
brook
blue-slime disease --------- 68, 70
calcium, radioactive ------- 154-158
fats, supplemental --------- 19-22
torula yeast ---------- 3-9
ulcer disease ---------- 43-49
brown
all-meal diet ---------- 110-112
antibiotics, vitamin B_{12} --- 148-153
biotin, pantothenic acid --- 67-70
eggs, viability ---------- 165-168
ulcer disease ---------- 44
cutthroat
columnaris ---------- 104-109
marking, trypan blue ------- 9
tagged ---------- 125-126
egg washer ---------- 116

Trout (continued)
feed dispenser. ---------- 124
lake
egg collection ---------- 131
growth ---------- 15-18, 71-73
production and losses ------ 49
scale studies ---------- 168
on a trolley in Oregon. ------- 37
production, time study -------- 87-97
rainbow
blue-slime disease --------- 67-68
columnaris ---------- 104-109
eggs, viability ---------- 165-168
red mouth disease ---------- 127-128
ulcer disease ---------- 44, 46
stocking, effect on catch ----- 117-121
Trypan blue ---------- 9

Urethane ---------- 9
Use of torula yeast in
the feeding of trout. --------- 3-9
Ulcer disease in brook
trout: its economic
importance, diagnosis,
treatment, and
prevention. ---------- 43-49

Van Cleve, Richard ---------- 159-164
Vitamin B_{12}, brown trout --------- 148-153

Wagner, E. D. ---------- 127-128
Walker, M. C. ---------- 129-130
Walleyed pike fingerling
production in drainable
constructed ponds
in Minnesota. ---------- 173-176
Wangersky, P. J. ---------- 153
Warmouth, blood study ---------- 169-172
Water temperatures,
relation to columnaris -------- 104-109
Weight
estimation method ---------- 76-78
relation to body
measurements, smelt -------- 50-55
Whitefish, spawning ---------- 38-39
Wilmot, R. L. ---------- 124
Wolf, L. E. ---------- 110-112, 148-153

Yeast, torula, trout diets ------- 3-9

Zilliox, R. G. ---------- 71-73

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